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Air Ambulance Helicopter Operational Analysis

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Final Report

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16. Abstract

This study of visual flight rules (VFR) weather minimums and operational areas for helicopter emergency medical service operators is based on operator responses to a questionnaire. The national average VFR operational weather minimums for all respondents was determined. Also, an estimate of the percentage of time that each respondent can not fly because of ceiling and/or visibil elow their VFR operating minimums was determined, as was the average percentage of time all sponders can not fly. Analysis of the data indicated that on the average the operators have voluntarily adopted stricter minimums than recommended in the current FAA Advisory Circular (AC) 135-14, "Emergency Medical Services/Helicopter (EMS/H)." Furthermore, the analysis indicated that on the average the operators have more restrictive daylight minimums than those in the proposed change to AC 135-14 and less restrictive night minimums than those in the proposed change. Some general observations about minimums for operations in mountainous areas are also provided.

The coverage areas reported by the operators were plotted on two maps of the United States, one for the local coverage areas and one for the cross country coverage areas. From these maps, the percentage of coverage for the conterminous United States, each FAA region, and each state were determined. The weather data were also averaged over each state and used to determine the percentage of time that coverage is available in areas where EMS/H service is provided.

The FAA is in the process of determining if there is an economic justification for the improvement of low altitude communication, navigation and surveillance services within the National Airspace System (NAS). A recent FAA study, Rotorcraft Low Altitude CNS Benefit/Cost Analysis (DOT/FAA/DS-89-11, September 1989) found that the helicopter ambulance mission is a source of significant social benefit. The results of the Air Ambulance Helicopter Operational Analysis provides data which will support further analysis of the benefits of air ambulance helicopters in an IFR environment.

17. Key Words
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TABLE OF CONTENTS

LIST OF FIGURES

Page

Page

LIST OF TABLES

1.0 INTRODUCTION

The Federal Aviation Administration (FAA) is in the process of determining if there is an economic justification for the improvement of low altitude communication, navigation, and surveillance (CNS) services within the NAS. A recent FAA study, Rotorcraft Low Altitude CNS Benefit/Cost Analysis (DOT/FAA/DS-89-11, September 1989) found that the helicopter ambulance mission was a possible source of significant social benefit. However, the magnitude of the societal benefit could not be accurately determined in that study for two reasons: 1) there was no accurate data available on the size of each air ambulance operator's operational areas, and 2) there was no accurate data available on the operator's weather minimums. The size of each operator's operational area is needed in order to claim benefits only for areas which actually have EMS helicopter coverage. The weather minimums data is necessary because the frequency and unscheduled nature of EMS operations lead to a high probability of encountering instrument meteorological conditions. Therefore, it is necessary to know when an operator would start declining to fly missions due to weather conditions. The publication of AC 135-14, "Emergency Medical Services/Helicopter (EMS/H)" in October of 1988, recommended that each operator establish specific local and cross-country operational areas, and weather minimums for both types of areas. The establishment of these operating areas and weather minimums made available, for the first time, the data necessary for an accurate benefit/cost analysis. The information gathered in this study will be used to support future FAA analysis of the benefits of air ambulance helicopters in an IFR environment and the low altitude CNS improvements that are necessary to achieve these benefits.

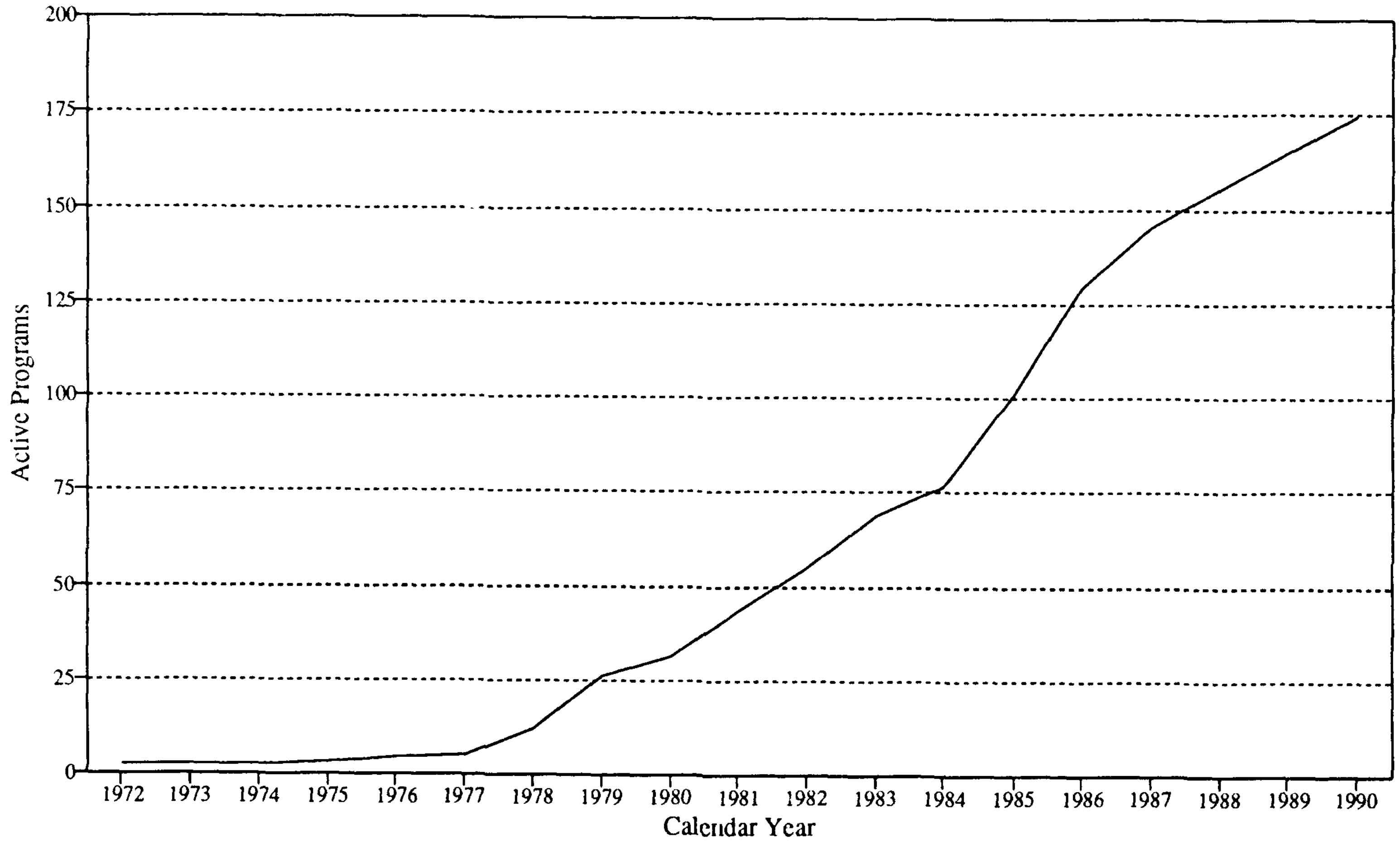
1.1 BACKGROUND

Emergency medical service helicopters are used to fly accident victims or critically ill patients to the location where they can receive the best medical treatment. EMS operations either fly established routes between contracting hospitals or pick-up victims directly at the site of the accident and fly them to a hospital. These operation scenarios are, on the average, divided on a 75 percent/25 percent ratio respectively, favoring the hospital transfers. While most EMS operations do not currently operate IFR, there is a small percentage who do and this percentage is increasing.

Emergency medical service has been the fastest growing helicopter mission of the last decade. The first two hospital-based EMS programs started in 1972. One new hospital-based operator per year started in 1975-77, then in 1978 seven hospital-based programs began and the trend kept going.

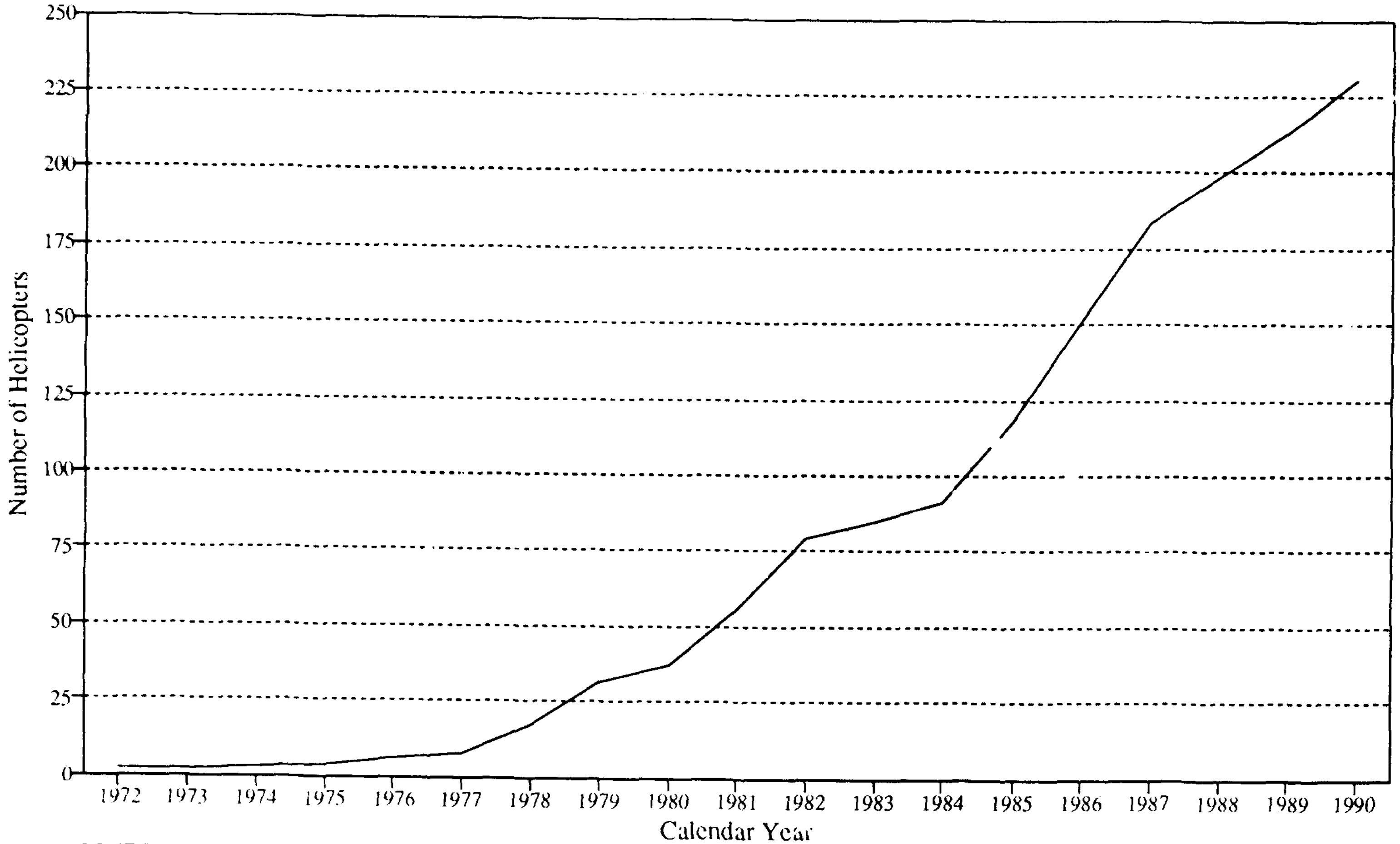
Figure 1 shows the annual increase in the number of hospital-based EMS helicopter programs and figure 2 shows the annual increase in the number of hospital-based EMS helicopters. The number of hospital-based EMS helicopter programs has been growing at a 9 percent annual rate since 1984 and the number of hospital-based helicopters used for EMS has been growing at a 10 percent annual rate since 1984.

According to <u>The Journal of Air Medical Transport</u>, February 1990, the four leading causes of EMS helicopter accidents from 1972 through 1989 were: adverse weather (21), obstacle strike (13), engine failure



SOURCE: "Hospital Aviation:", 1990

FIGURE 1 ACTIVE HOSPITAL-BASED EMS PROGRAMS



SOURCE: "Hospital Aviation:", 1990

NOTE: This figure does not include the many helicopters that are used primarily for other missions and are used for EMS on a part--time basis.

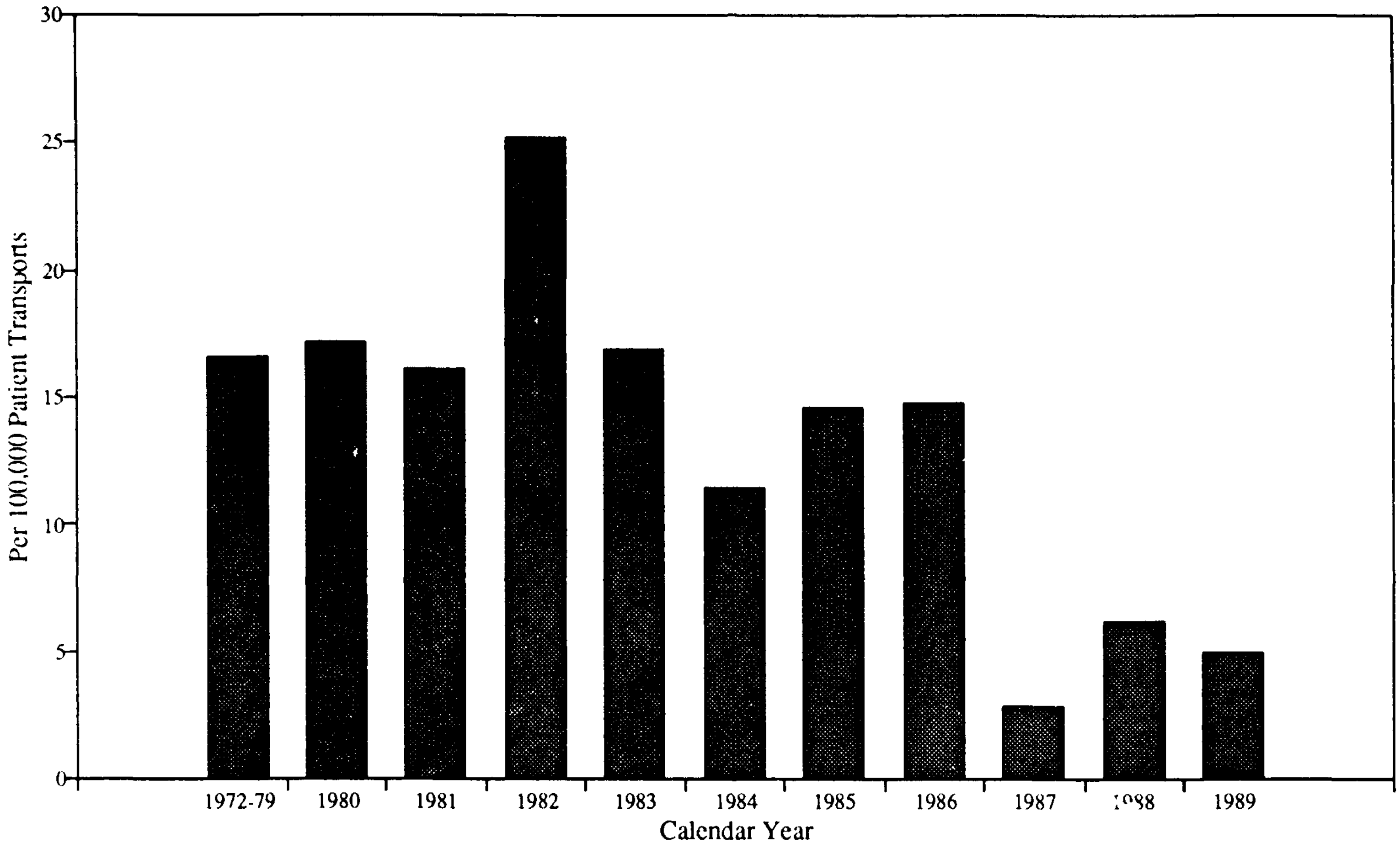
FIGURE 2 NUMBER OF HELICOPTERS IN HOSPITAL-BASED EMS

(12), and control loss (8). All other causes combined were responsible for 18 accidents. Figure 3 shows the annual air medical helicopter accident rate. Figure 4 shows the total number of air medical helicopter accidents each year. From 1972 through 1989, adverse weather accounted for 29 percent of all accidents, however, the percentage dropped to only 17 percent of the 1989 accidents. Thus it can be shown that adverse weather has historically been a significant factor in EMS helicopter accidents.

In response to the increased use of EMS helicopters and public safety concerns, the FAA issued Advisory Circular (AC) 135-14, "Emergency Medical Services/Helicopter." This AC provides information and guidelines to assist EMS/H operators in the conduct of their operations. One of the suggested guidelines covers weather minimums and will be covered in detail in section 3.1 of this report.

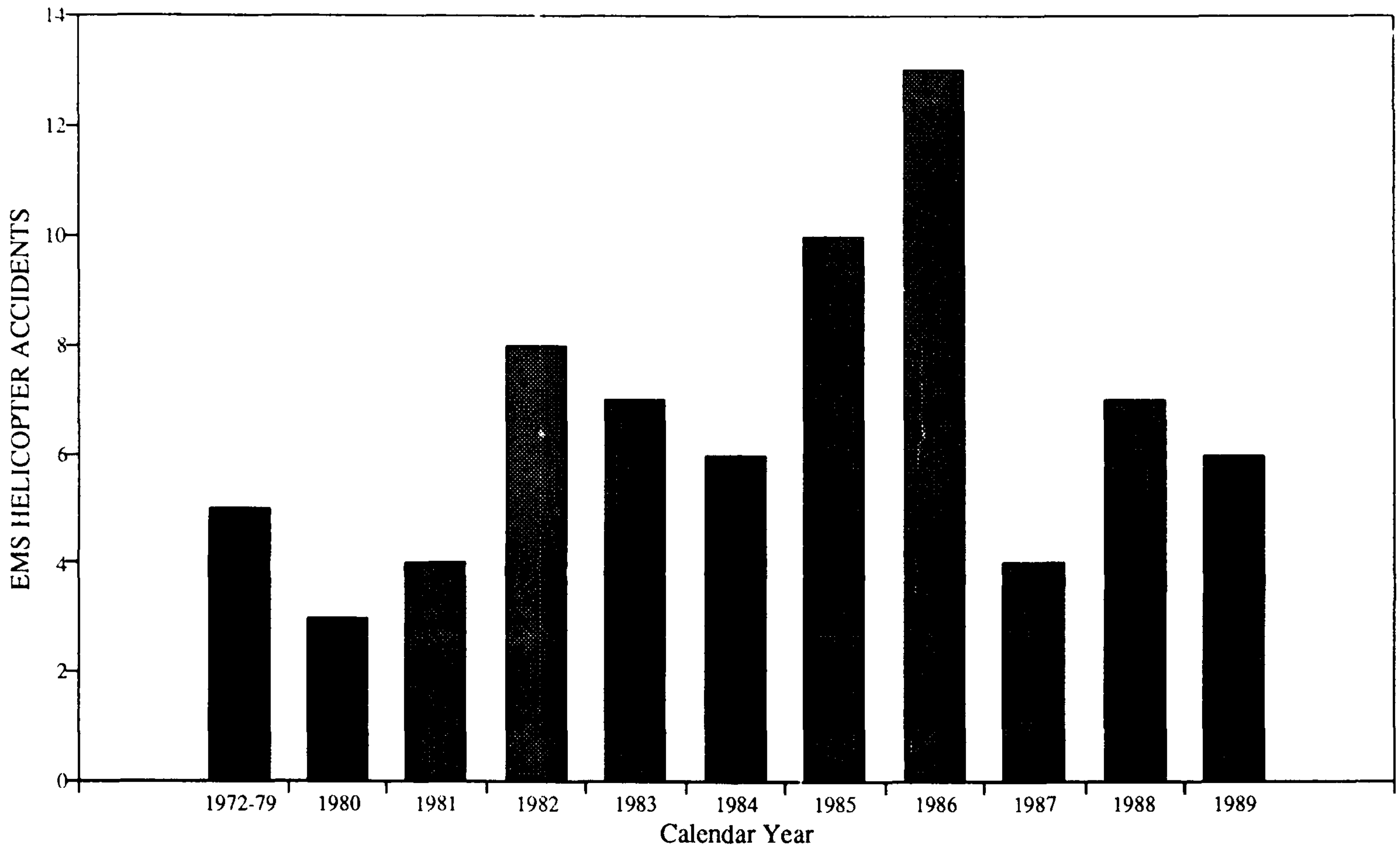
This study of visual flight rules (VFR) weather minimums and operational areas for emergency medical service/helicopter (EMS/H) operators is based on operator responses to a request for information regarding operators' weather minimums (see appendix B). The national average VFR operational weather minimums for all respondents were determined. Also, an estimate of the percentage of time that each respondent cannot fly because of ceiling and/or visibility below their VFR operating minimums was determined, as was the average percentage of time all responders cannot fly. Analysis of the data indicated that on the average that operators have voluntarily adopted stricter minimums than recommended in the current FAA Advisory Circular (AC) 135-14, "Emergency Medical Services/Helicopter (EMS/H)" which was published on 20 October 1988. Furthermore, the analysis indicated that on the average the operators have more restrictive daylight minimums than those in the proposed change to AC 135-14 and less restrictive night minimums than those in the proposed change. Some general observations about minimums for operations in mountainous areas are also provided.

The coverage areas reported by the operators were plotted on two maps of the United States, one for the local coverage areas and one for the cross country coverage areas. From these maps, the percentage of coverage for the conterminous United States (CONUS), each FAA region, and each state was determined. The weather data was also averaged over each state and used to determine the percentage of time that coverage is available in areas covered by EMS/H service.



SOURCE: "The Journal of Air Medical Transport", February 1990

FIGURE 3 AIR MEDICAL HELICOPTER ACCIDENT RATE



SOURCE: "The Journal of Air Medical Transport", February 1988 and 1990

FIGURE 4 TOTAL EMS HELICOPTER ACCIDENTS PER YEAR

2.0 METHODOLOGY

In June of 1989, the Federal Aviation Administration (FAA) through the Vertical Flight Program Office (ARD-30) sent a letter requesting information to all known EMS/H operators. Each EMS/H operator's weather minimums (ceiling and visibility) were requested for both their local and cross country operating areas. The weather minimums were organized in a database and linked to weather data derived from the FAA's Airport Specific File. This linkage made it possible to analyze the effect of various weather minimums on EMS/H operations. The minimums considered in this study are: 1) the EMS/H operators' company minimums, 2) the AC 135-14 minimums, and 3) the proposed FAA change to the minimums in AC 135-14.

In addition, each operator was requested to provide a map with the boundaries of their local and cross country operating areas depicted. The size of each operating area, in square miles, was taken from the map sheets and entered into the database. Furthermore, a composite map of all the respondents' operating areas was created, one map for all of the local operating areas and one map for all of the cross-country operating areas. Individual maps of each FAA region and state (including adjacent areas) were made from the composite maps. All maps are provided in appendix A.

2.1 EMS/H OPERATOR SURVEY

The names and addresses of 179 EMS/H operators were obtained from the March 1989 edition of The Journal of Air Medical Transport. In June of 1989, a letter requesting information was sent to each operator. In December of 1989, a follow-up letter was sent to all non-respondents. A total of 153 EMS/H operators returned complete data packages, a response rate of 85.5 percent. A total of 149 respondents reported operations from a single base, and 4 public service operators reported multiple (22) bases of operation. The California Highway Patrol reported seven bases, the Maryland State Police reported seven bases, the Illinois Department of Transportation reported four bases, and the Arizona State Police reported four bases. Therefore, 171 (149 + 22) locations were entered into the database. An additional 27 operators returned incomplete data packages or answered phone inquiries that were suitable only for use in developing the maps of coverage areas, bringing the total number of locations in the database to 198.

Each operator provided information on their company VFR weather minimums for the four operating conditions recommended in AC 135-14: day/local, day/cross country, night/local and night/cross country. The data on company VFR minimums was organized in a database using database management software. In addition, a few of the operators provided comments on particular operational constraints in their areas of operation. All of these comments have been indexed and put into the database. A sample letter requesting information is provided in appendix B.

2.2 AIRPORT SPECIFIC FILE

The Airport Specific File (ASF) is a computer database, developed by the FAA Office of Policy and Plans (APO-220). It contains data describing airport facilities and equipment, weather probabilities, and

aircraft ceiling and visibility requirements for 1,637 airports in the United States. For more information on the ASF, see "Development of Revised and Expanded Airport Specific File Data for the Airport Criteria Data System," Report No. FAA-APO-86-8, December 1985.

For the purposes of this study, only the weather probability data was used from the ASF. The weather data was linked to the EMS/H database by county and state. First, the county where each operator was located was identified using the operator's mailing address and a database containing all the zip codes and counties in the United States. Second, the same zip code/county database was used with a database of FAA Form 5010s, the Airport Master Record, to find the county of each heliport/airport in the United States with based helicopters. The operator's county was then matched with an airport in the same county. The airport's site identifier was found in the ASF and its weather probabilities were extracted.

The percentage of time that VFR minimums are not met at each location was calculated for all four operating conditions in AC 135-14 for 1) the company minimums, 2) the AC 135-14 minimums, and 3) the proposed change to the AC 135-14 minimums. In all, 12 different weather probability percentages were calculated for each operator's location.

One problem encountered is that the weather data in the ASF contains information on the joint (combined) probability of the weather exceeding both a ceiling and a visibility limit. However, data in the ASF is supplied for only eight combinations of ceiling and visibility limits. It is not possible to determine the unconditional (independent) probability of either the ceiling or the visibility being exceeded with this data. Nor is it possible to compute the joint probabilities for all of the various combinations of ceiling and visibility minimums used by EMS/H operators. Both of the above limitations are significant for this study. Therefore, the model of average weather probabilities for the United States, from which the data in the ASF was derived, was used to construct a second model in order to determine the specific ceiling and visibility probabilities for the areas of interest in this study. In effect, the national average weather model, corrected for each location's site specific data, was used to calculate the weather probabilities for all 171 locations. Appendix C contains an explanation of the weather models and their applications in this study.

Another problem encountered with the ASF data was that it only reports on weather during daylight hours. A second source of weather data was consulted (see appendix C) and it was found that at most locations the probabilities do not vary much from day to night. Any variation was usually on the order of 1 or 2 percent. However, there was no pattern to whether the weather was better or worse between night and day. The reader is cautioned about the application of the results of this study to individual locations during the hours of darkness. However, the averaged results are thought to be relevant. Any error introduced will be the same for all of the weather conditions examined in this report. Therefore, no bias should have been introduced to the averages discussed later in section 3.1.

3.0 RESULTS

The data was analyzed for trends in the VFR minimums reported by the operators. Estimates were calculated for the percent of time that each location was below the company minimums, below AC 135-14 minimums, and below proposed AC 135-14 minimums. In addition, the data was averaged over an entire state to determine the percentage of time that the weather is better than the operators' minimums in those areas where EMS service is provided. This statistic is termed the "weather availability."

3.1 ANALYSIS OF VFR MINIMUMS

The average ceiling, visibility, and percentage of time that VFR weather minimums are not met were calculated. The results are provided in tables 1 and 2. The data in table 1 shows that the average ceiling and visibility minimums increase in a logical manner as the operating conditions become more difficult. The minimums increase both from local to cross country and from day to night.

TABLE 1 AVERAGE EMS/H VFR OPERATING MINIMUMS
(Sample Size: 153 Operators)

Conditions	Ceiling	Visibility
Day/Local	579	1.4
Day/Cross Country	790	2.1
Night/Local	921	2.7
Night/Cross Country	1,242	3.5

TABLE 2 AVERAGE PERCENTAGE OF TIME VFR MINIMUMS NOT MET
(Sample Size: 153 Operators)

Conditions	AC 135-14		Company	Proposed AC 135-14	
Day/Local	(500/1)	2.9%	4.3%	5.3%	(800/1)
Day/Cross Country	(800/2)	6.4%	6.7%	7.8%	(1,000/2)
Night/Local	(800/2)	6.4%	8.3%	7.8%	(1,000/2)
Night/Cross Country	(1,000/3)	9.3%	11.5%	10.7%	(1,300/3)

Note: The notation (500/1) means 500 feet ceiling and 1 mile visibility minimums.

Table 2 shows the percentage of time that the weather conditions are below VFR minimums averaged across all of the operators. In addition, table 2 shows the current and proposed AC 135-14 minimums in parentheses. The reader is asked to refer back to table 1 for the average company minimums. Note that in all cases the current AC 135-14 minimums are less restrictive than the average company minimums in terms of the percentage of time that VFR operations are allowed. In other words, on average, the EMS/H operators have voluntarily adopted minimums more restrictive than the minimums recommended in AC 135-14. Also note that the proposed changes to the AC are more restrictive than the current company average minimums during the day and less restrictive than the company average minimums during the night.

It appears that the operators are more restrictive on night visibility minimums than is the proposed change to AC 135-14. The operators' average night visibility minimums for local and cross-country are 2.7 miles and 3.5 miles, respectively; the proposed AC 135-14 visibility minimums are 2.0 miles and 3.0 miles, respectively. The night ceiling minimums for both the company and the proposed change to AC 135-14 minimums are approximately equal.

The company minimums and the proposed change to AC 135-14 are much closer for the day/local and the day/cross-country conditions. In these cases, the visibility limits match closely; however, the change to the AC has slightly more restrictive ceilings, about 200 feet higher for each condition. The effects of these more restrictive minimums will be discussed later in this section.

In addition to computing the average ceiling and visibility minimums, histograms of the frequency distributions of the data were developed. Figures 5 through 12 show the frequency distributions of the data for the four operating conditions discussed above. The odd numbered figures show ceiling data and the even numbered figures show visibility data. Note that the class limits for the ceiling histograms increase in 100 feet increments from 300 to 1,000 feet and then in 500 feet increments from 1,001 feet to 2,500 feet.

The non-normal statistical distribution of the data is obvious. In many of the distributions, there are two or more spikes depicting high numbers of operators separated by large areas of low numbers of operators. This would be expected of a population encompassing such a large variation of operators and operating areas. For example, public service operators in flat areas like Arizona and conservative private operators in the mountainous areas of Colorado or Pennsylvania have greatly differing minimums. The standard deviations of the minimums were calculated and are presented in table 3. Confidence intervals were not calculated because of the non-normal data distribution.

TABLE 3 STANDARD DEVIATIONS OF VFR MINIMUMS
(Sample Size: 153 Operators)

Conditions	Ceiling (feet)	Visibility (miles)
Day/Local	162	0.5
Day/Cross-Country	256	0.7
Night/Local	234	0.7
Night/Cross-Country	449	1.0

For the day/local operating condition, figures 5 and 6 reveal several trends. There are two spikes in the ceiling minimums, at the 500 foot and 800 feet class limits. These spikes contain 82 percent of all the operators, with 61.4 percent using the 500 feet minimum and 21.1 percent using the 800 foot minimum. The current AC 135-14 minimum for day/local is 500 feet; the proposed change is to 800 feet. Only 5.8 percent of the operators have an altitude ceiling less than 500 feet. However, 76.6 percent of the operators have a ceiling less than 800 feet. There is no change proposed to the AC 135-14 visibility minimum; it remains at 1 mile. A predominant 62 percent of the operators use 1 mile as their visibility minimum and the rest all use higher visibility requirements. This is in agreement with the AC's recommendation, and no operations

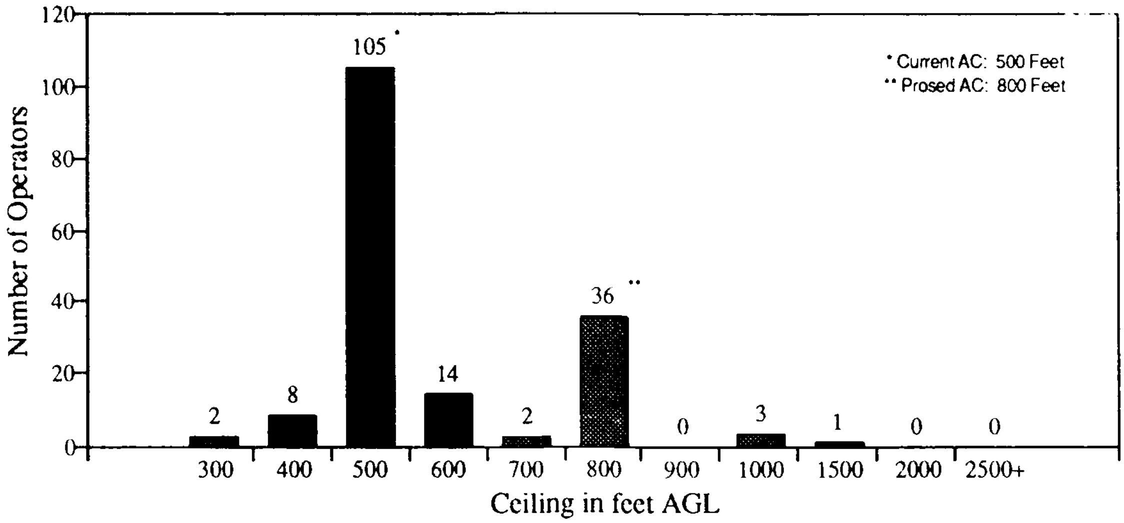


FIGURE 5 FREQUENCY DISTRIBUTION OF COMPANY ALTITUDE CEILINGS DAY/LOCAL OPERATING AREA

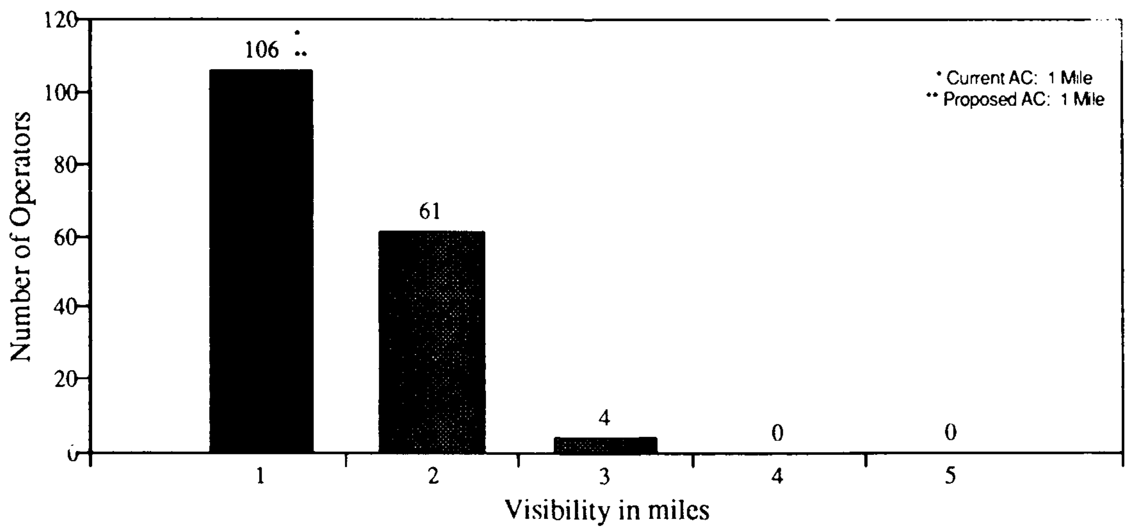


FIGURE 6 FREQUENCY DISTRIBUTION OF COMPANY VISIBILITY MINIMUMS DAY/LOCAL OPERATING AREA

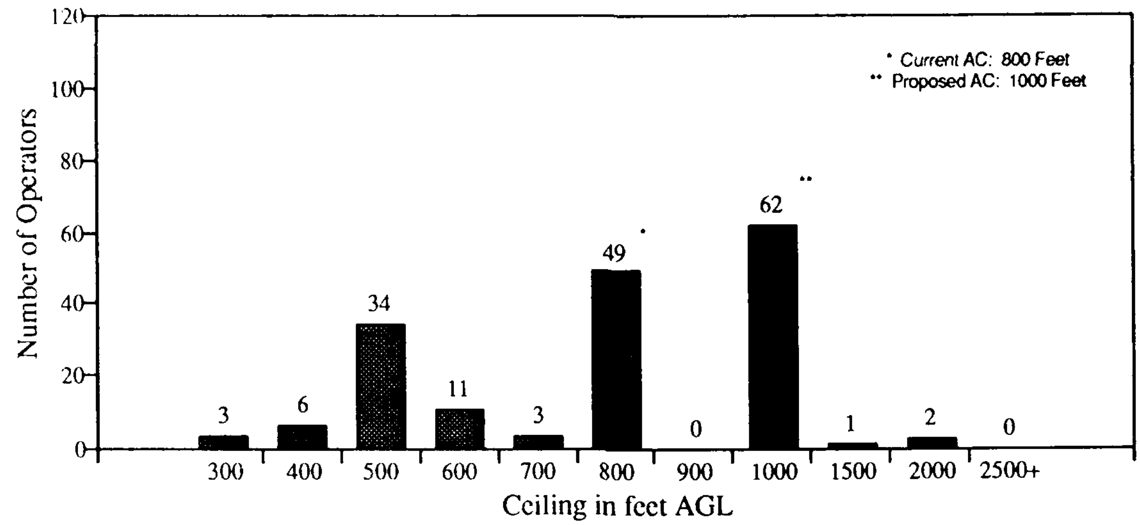


FIGURE 7 FREQUENCY DISTRIBUTION OF COMPANY ALTITUDE CEILINGS
DAY/CROSS-COUNTRY OPERATING AREA

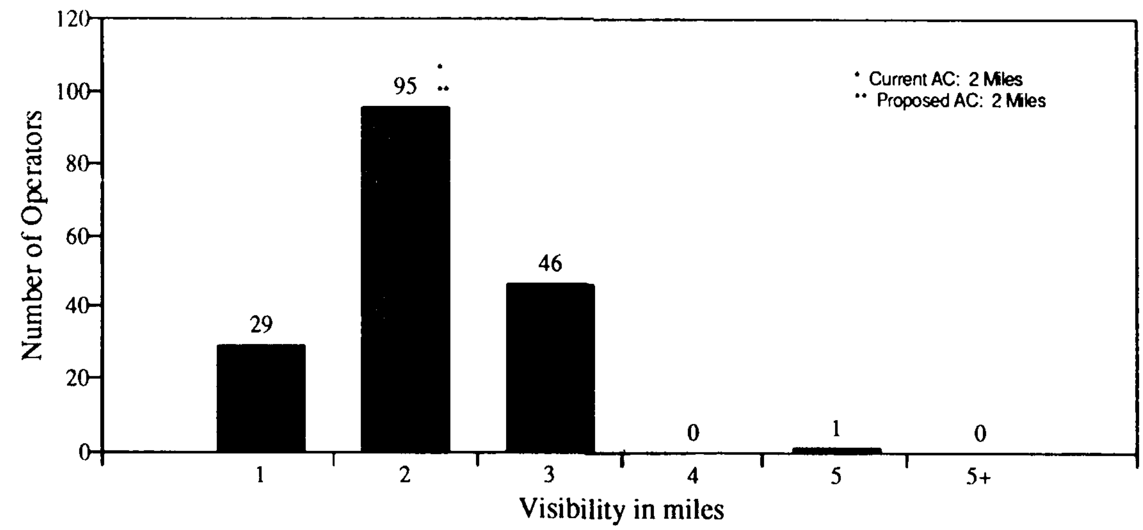


FIGURE 8 FREQUENCY DISTRIBUTION OF COMPANY VISIBILITY MINIMUMS
DAY/CROSS-COUNTRY OPERATING AREA

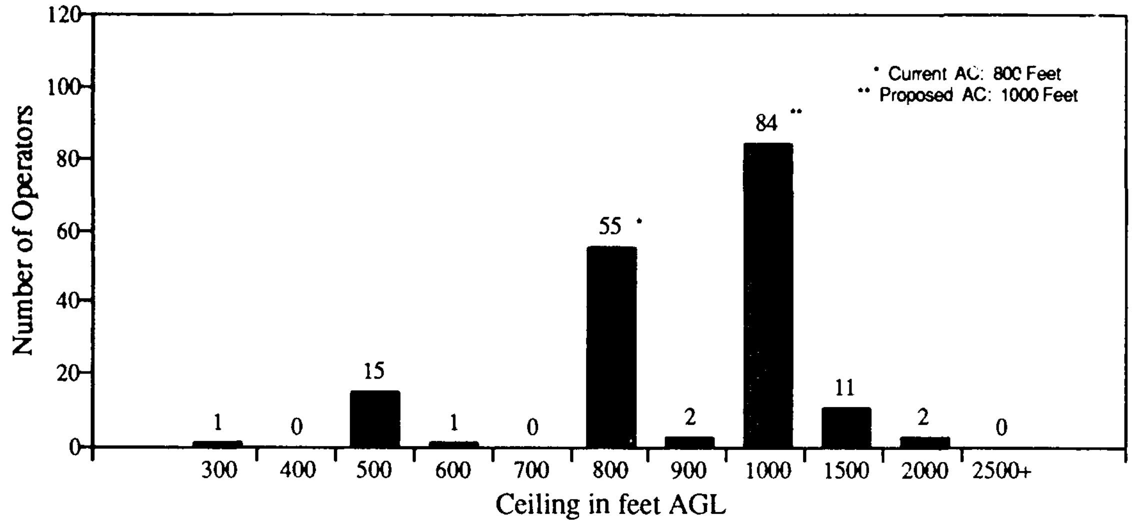


FIGURE 9 FREQUENCY DISTRIBUTION OF COMPANY ALTITUDE CEILINGS
NIGHT/LOCAL OPERATING AREA

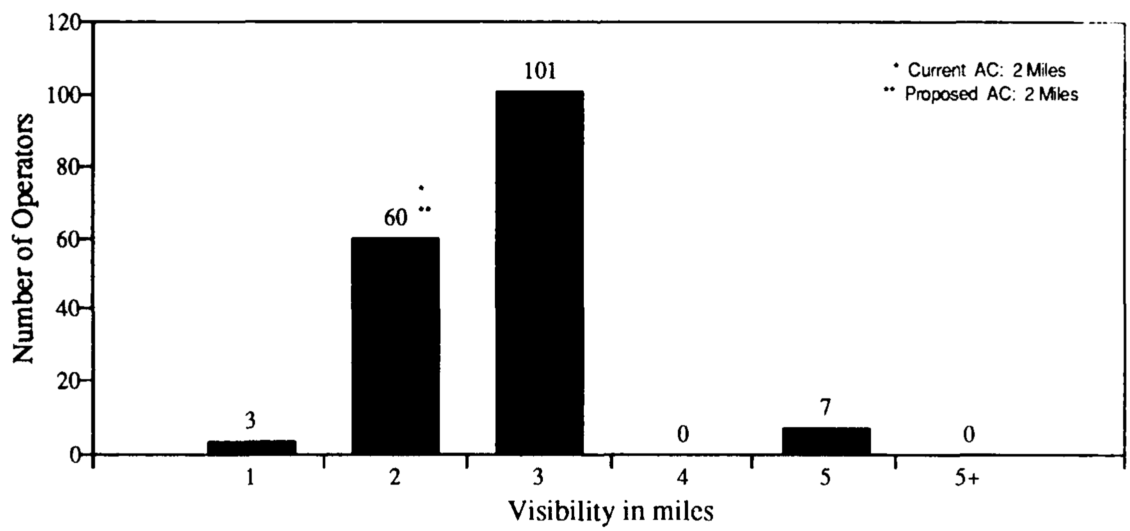


FIGURE 10 FREQUENCY DISTRIBUTION OF COMPANY VISIBILITY MINIMUMS
NIGHT/LOCAL OPERATING AREA

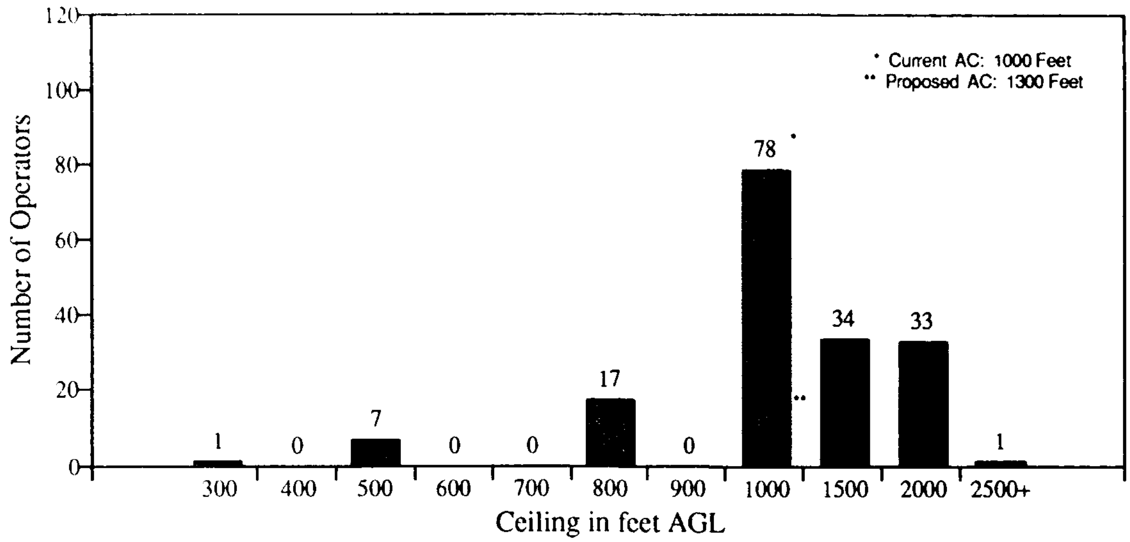


FIGURE 11 FREQUENCY DISTRIBUTION OF COMPANY ALTITUDE CEILINGS NIGHT/CROSS-COUNTRY OPERATING AREA

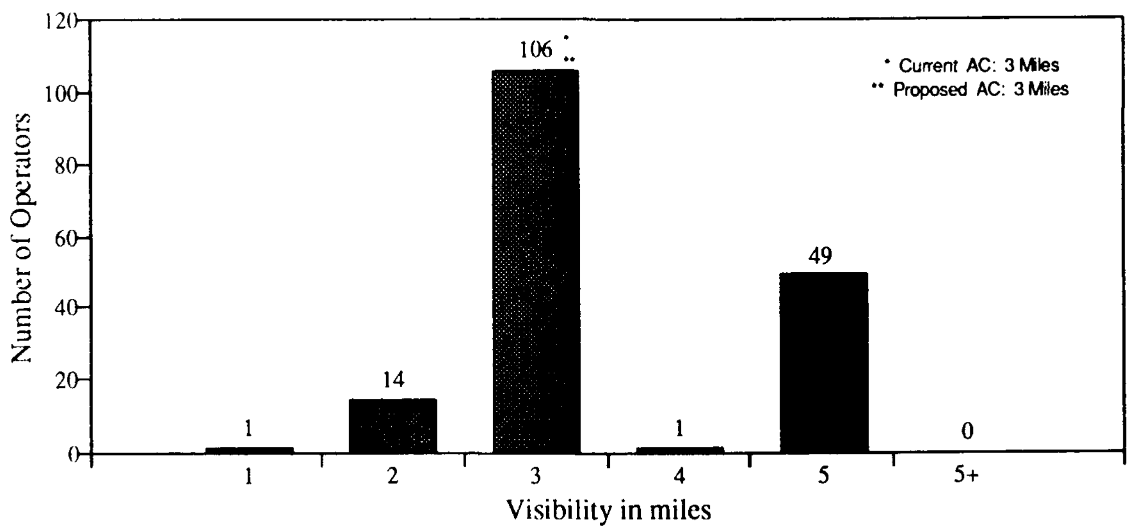


FIGURE 12 FREQUENCY DISTRIBUTION OF COMPANY VISIBILITY MINIMUMS NIGHT/CROSS-COUNTRY OPERATING AREA

would be further curtailed by adopting the proposed AC 135-14 visability minimums.

For the day/cross country operating condition, figures 7 and 8 reveal several trends. There are three spikes in the ceiling minimums, at the 500 feet, 800 feet and 1,000 feet class limits. The spikes contain 84.8 percent of all the operators, with 19.9 percent using the 500 feet minimum, 28.7 percent using the 800 feet minimum, and 36.3 percent using the 1,000 foot minimum. The current AC 135-14 minimum is 800 feet; the proposed change is 1,000 feet. Only 33.3 percent of the operators have an altitude ceiling less than 500 feet. However, 62.0 percent of the operators have a ceiling less than 1,000 feet. There is no change in the AC 135-14 visibility minimum; it remains at 2 miles. A predominant 55.6 percent of the operators use a 2 mile minimum, However, 17 percent of the operators use a 1 mile minimum.

For the night/local operating condition, figures 9 and 10 reveal several trends. There are two spikes in the ceiling minimums, at the 800 feet and the 1,000 feet class limits. The spikes contain 81.3 percent of all the operators, with 32.2 percent using the 800 foot minimum and 49.1 percent using the 1,000 feet minimum. The current AC 135-14 minimum is 800 feet; the proposed change is 1,000 feet. Only 9.9 percent of the operators have an altitude ceiling less than 800 feet. However, 43.3 percent of the operators have a ceiling less than 1,000 feet. There is no change in the AC 135-14 visibility minimum; it remains at 2 miles and is used by 98.2 percent of the operators. Currently, 35.1 percent of the operators use a 2 mile minimum, and 59.1 percent of the operators use a 3 mile minimum.

For the night/cross country operating condition, figures 11 and 12 reveal a strong tendency towards high minimums for both ceilings and visibility. There are only 25 operators, 14.6 percent, that use ceiling minimums lower than 1,000 feet, which is the existing AC 135-14 suggested minimum. In fact, 45.6 percent of all operators use a 1,000 feet minimum. However, the proposed change to the AC suggests a 1,300 feet minimum. This would affect the operations of 64.3 percent of the operators if it was adopted. There is no proposed change to the visibility minimum; it remains at 3 miles. Approximately 62 percent of the operators use 3 miles as their company minimum. Another 28.7 percent use 5 miles as their company minimum. Only 8.8 percent of the operators use a minimum lower than the suggested 3 miles.

3.2 ANALYSIS OF MINIMUMS IN A MOUNTAINOUS AREA

A few operators reported that they have separate minimums for flights over mountainous areas. Unfortunately, of the 29 operators that reported operating in mountainous areas, only 16 reported any minimums at all. Even among the 16 that reported separate mountain minimums, the reporting was frequently incomplete. However, some interesting insights may be gained from analysis of the average minimums for mountainous areas.

Of the 12 operators in mountainous areas that provided full information for all 4 operating conditions, 10 made no distinction between local and cross country operating conditions. In other words, they used the same minimums for day/local and day/cross-country, and they used the same minimums for night/local and night/cross-country. The other two operators used the minimums suggested in the current AC 135-14 (see table 4).

TABLE 4 AVERAGE VFR MINIMUMS FOR MOUNTAINOUS AREAS
(Sample Size: 12 Operators)

Conditions	AC 135-14	Company	Proposed Change
Day/Local	500/2	918/2.7	1,000/3
Day/Cross Country	800/3	962/2.8	1,200/3
Night/Local	800/3	1,827/4.4	1,200/3
Night/Cross Country	1,000/3	1,823/4.3	1,500/3

Table 4 shows the average mountain minimums for the operators, the current AC 135-14 mountain minimums, and the proposed AC 135-14 mountain minimums. Note that the operators' average minimums are somewhat higher than the current AC 135-14 minimums for all operating conditions. Also note that the proposed change to AC 135-14 is slightly more restrictive than the average company minimums under daylight conditions, but significantly less restrictive under night conditions. It is impossible to make generalizations based on this small sample. However, it appears that the operators are already taking a cautious approach to mountain operations.

3.3 OPERATOR'S COMMENTS

A few of the operators chose to send comments about their operating minimums, operating conditions, and anything else they considered relevant even though comments were not specifically requested. Since the majority of respondents chose not to send comments, no percentages have been calculated. A categorization of operator comments is shown in table 5, as well as a synposis of all of the comments in each category.

TABLE 5 OPERATOR COMMENTS

Comment Category	Number
Use of multiple minimums	41
Mountainous operating areas	29
Lack of adequate weather reporting	27
Communications requirements to ATC or base hospital	16
Surveillance requirements	15
Instrument flight rules operations	12
Navigation requirements	18
Fog conditions	3

Comments

1. Multiple Minimums
   - "Aircraft not equipped with a stability augmentation system (allowing the pilot at least short term hands-off flying capability) will increase local flying minimums by 200 feet and 1 mile."

2. Mountainous Operating Areas
   - "Nighttime scene landings in mountainous terrain are prohibited unless the destination is an approved predesignated area."

- "XXXX has additional (more restrictive) minimums for operations in mountainous terrain."

- "I consider any pilot who has not had extensive experience in mountain flying to be a new pilot and place him on higher minimums."

3. Weather Reporting
   - "We...have a significant problem obtaining any weather information for flights after 10 pm."

   - "Many of the small hospitals and airports that we serve have no weather facilities...we must rely on observations from the closest facility or area weather forecasts. If there is any question as to whether we can safely complete the flight in accordance with applicable FARs, the flight is refused. This limitation also affects our fixed-wing operations...

   - "When weather is bad it is difficult to get through to FSS because everyone is calling."

4. Communications
   - "We have found a lack of FAA's capability in flight following in the southern areas of the state."

   - "Whenever an aircraft is to be operated outside the hospital radio net, the area manager shall be notified that the aircraft will be utilizing an FAA flight plan and the circumstances surrounding the flight."

5. Surveillance
   - "Radar coverage, especially at our altitudes, is not available."

   - "Discrete transponder code from ATC would greatly reduce cockpit workload..."

6. IFR
   - "SVFR operations between XXXX airport and XXXX hospital are authorized at night with minimums of 500 feet and 1 mile for the purpose of beginning and ending an IFR flight."

   - "The lack of enough navigation facilities results in MRAs that are so high as to be impractical for helicopters. Furthermore, there are some blank areas where no voice reception is available below 10,000 feet."

   - "We could definitely use additional instrument approaches at airports that do not have them and upgraded instrument approaches at airports that have only non-precision approaches."

   - "They desire to implement Loran-C point-in-space approaches to the outlying hospitals in their catchment area.... The availability of additional low altitude communications sites would greatly enhance the safety and operation of their program."

- "Our IFR operations, however, are greatly limited because of the lack of weather reporting stations. We continue to have to abort lifesaving missions or fly in marginal VFR conditions because weather reporting is grossly inaccurate or nonexistent. In order to expand our IFR capabilities, we intend to apply for an exemption to 14 CFR 135.213, which requests a qualified weather observer to be on the destination airport. We would like to be able to file IFR to destinations which have current observations from another airport within 50 nm. This would quadruple our legal IFR destinations; however, we still have the problem of night closings (of weather stations). Our intent here is not really to be able to fly in much worse weather, but to fly more safely when marginal weather conditions exist."

7. Navigation Requirements
   - "XXXX has no local operating area; however, it does follow the roads for many of its operations. It operates in extremely mountainous terrain, and the roads follow the valleys."

   - "Our primary navigation aid is Loran-C. VORs do not provide adequate coverage in our area, particularly at low altitudes."

   - "Single pilot night operations shall be limited to lighted airports, permanent heliports and predesignated temporary heliports."

8. Fog
   - "...our aircraft crashed into a mountaintop and all three crew members were killed. Fog in the mountains was a factor in the crash."

3.4 ANALYSIS OF COVERAGE AREAS

The maps of coverage areas provided by the EMS/H operators were analyzed to determine: 1) the percentage of CONUS (48 states), each FAA region and each state area currently provided with EMS/H service; 2) the average size of operating areas in CONUS, in each FAA region and in each state; and 3) the weather availability in areas where coverage is provided. Weather availability is defined as the percentage of time that the weather is better than the operator's minimums.

As the analysis of coverage areas is developed in the following paragraphs, reference to the maps in appendix A provides visual reinforcement of the discussion. All maps in appendix A are itemized in the list of figures on pages iv through vi of this report. The maps are organized in the following manner, first, the local coverage areas are presented, arranged with a map showing CONUS coverage first, then showing FAA regional coverage, and finally individual state coverage arranged alphabetically. Next, the cross country coverage areas are presented, following the same arrangement as the local maps. Items of particular interest are pointed out in the following paragraphs. The shaded areas indicate areas where coverage is present. On the cross-country maps, areas of double shading indicate coverage by only one operator, while areas of single shading indicate coverage by multiple operators.

A glance at figure A-57, the CONUS cross-country coverage map, makes clear the reason for this seemingly backwards presentation of coverage areas. Almost 80 percent of CONUS is covered by multiple EMS/H operators, while over 13 percent of CONUS is covered by a single EMS/H operator. Less than 7 percent of CONUS is not covered by an EMS/H operator, although even these areas probably have access to fixed-wing EMS or military assistance to safety and traffic (MAST) flights. The dashed lines on the cross country operating areas within Wyoming and Missouri indicate that the operator specified distinct destinations rather than a boundary for his/her operations.

3.4.1 Percentage of the Area of the United States Covered by EMS/H Service

Table 6 shows the percentage of each FAA region which is covered by EMS/H operators' local and cross country operating areas. The percentage of local coverage ranges from 13 percent in the Central Region to 78 percent in the Western-Pacific Region. The percentage of CONUS as a whole that has local coverage is 31 percent. The reason that the Western-Pacific Region's percentage of coverage is so much larger than all of the other regions and CONUS is due to the presence of public-service EMS/H operators in two out of the three CONUS states, California, Arizona, and Nevada, in the Western-Pacfic Region. (Hawaii has been left out of the analysis since it is not part of CONUS and it lacks EMS/H operators.) The public-service operators in Arizona and California provide service, both local and cross-country, over 100 percent of their respective states. Interestingly, the percentage of cross-country coverage in the Western Pacific Region is lower than every other CONUS region except for the New England Region. This is due to the large, mostly desert areas of Nevada in which no service is provided. Figures A-2 through A-9 illustrate the local area coverage available in each region.

TABLE 6 COVERAGE AREAS FOR CONUS AND FAA REGIONS (in square miles)

Region	Regional Area	Local Coverage		Cross Country Coverage	
New England	63,012	9,250	15%	27,477	44%
Eastern	175,334	81,314	46%	164,226	94%
Southern	370,105	128,051	35%	367,875	99%
Great Lakes	468,772	63,544	14%	457,859	98%
Central	283,332	37,889	13%	283,332	100%
Southwest	549,714	85,073	15%	486,686	89%
Western Pacific*	379,702	295,841	78%	325,625	86%
NW Mountain	673,162	207,024	31%	650,043	97%
Alaskan	570,833	266,349	47%	266,349	47%
CONUS (48 States)	2,963,133	907,986	31%	2,763,123	93%
TOTAL U.S.	3,540,393	1,174,335	33%	3,029,472	86%

* excluding Hawaii

The percentage of cross-country coverage ranges from a low of 44 percent in the New England Region to a high of 100 percent in the Central Region. The percentage of cross-country coverage in the Eastern,

Southern, Great Lakes, and Northwestern Mountain Regions is also almost complete. Figures A-58 through A-65 illustrate the cross-country coverage available in each region. Cross-country coverage over CONUS is 93 percent.

The percentage of each state provided with EMS/H coverage, both local and cross-country, is presented in tables 7, 8, and 9. Each table contains the same information organized in a different manner. Table 7 presents the coverage data organized alphabetically by state. Each state's total area, local coverage area, percentage of local coverage, cross-country coverage area, and percentage of cross-country coverage are presented. Table 8 presents the same data as table 7, this time organized by percentage of cross-country coverage. This table clearly illustrates that 32 of the states are completely covered by an EMS/H operator's cross-country operating area. Another six states are more than 95 percent covered. Only two states, Maine and Hawaii, have less than 45 percent cross-country coverage. A general observation is made that all of the states with less than 95 percent cross country coverage are noted for having large undeveloped areas and low population densities.

Table 9 presents the same data as tables 7 and 8, this time organized by percentage of local coverage. There are only four states with 100 percent local coverage; all four of them are served by state-sponsored public service operators. There are seven public service operators included in this study. However, there are also other EMS/H operators providing service in all of these states. At the other extreme, there are five states, North Dakota, Maine, New Hampshire, Vermont, and Hawaii, which have no local EMS/H coverage. With the exception of Hawaii, all of the states with no local coverage are states on the northern United States border which have low population densities. As with the percentage of cross-country coverage, a low percentage of local coverage is associated with states, or areas within states, having low population densities. For example, only the most northern part of New York does not have coverage.

The Honolulu Fire Department Helicopter Division was contacted about the lack of EMS/H in Hawaii, and the Chief Fire Inspector on duty responded that the high cost of operating helicopters and the presence of adequate MAST coverage over the entire state are probably responsible for the lack of EMS/H in Hawaii. He stated that there was a hospital-based helicopter in Honolulu but that it went out of business because of high cost.

3.4.2 Geographic Size of EMS/H Operating Areas

Table 10 shows the average size of EMS/H coverage areas for each FAA region and CONUS. The size is reported both as an average area and as an average radius for both the local and the cross-country operating areas. In addition, the number of operators in each region is reported. Note that there are 185 operators that provide local coverage in CONUS, while there are 196 operators that provide cross-country coverage. This type of variation can be seen in four of the regions as well The reason for this variation is that some operators provide only cross-country service. However, there are no operators that reported providing only local service. Of the 11 operators that reported no local operating areas, 4 were public service operators, 1 operated in a mountainous environment, which might have influenced the decision not to fly local

TABLE 7 EMS CROSS-COUNTRY AND LOCAL COVERAGE - LISTED IN ALPHABETICAL ORDER BY STATE

STATE	STATE AREA*	LOCAL COVERAGE AREA*	LOCAL COVERAGE PERCENT	CROSS COUNTRY COVERAGE AREA*	CROSS COUNTRY COVERAGE PERCENT
AK	570833	266349	46.7	266349	46.7
AL	50776	4637	9.1	50308	99.1
AR	53187	5264	9.9	53187	100.0
AZ	113510	113510	100.0	113510	100.0
CA	156297	156297	100.0	156297	100.0
CO	103598	13258	12.8	103598	100.0
CT	4872	4439	91.1	4872	100.0
DE	1933	1561	80.8	1933	100.0
FL	54157	42647	78.7	54157	100.0
GA	58060	23086	39.8	56298	97.0
HI	6427	0	0.0	0	0.0
IA	55965	13354	23.9	55965	100.0
ID	82413	24409	29.6	82413	100.0
IL	55646	9943	17.9	55646	100.0
IN	35936	12944	36.0	35936	100.0
KS	81783	7559	9.2	81783	100.0
KY	39674	13940	35.1	39674	100.0
LA	44520	25090	56.4	44520	100.0
MA	7826	4712	60.2	7826	100.0
MD	9838	9838	100.0	9838	100.0
ME	30995	0	0.0	1546	5.0
MI	56959	11181	19.6	48773	85.6
MN	79548	5578	7.0	79548	100.0
MO	68945	8476	12.3	68945	100.0
MS	47234	11470	24.3	47234	100.0
MT	145388	97103	66.8	131491	90.4
NC	48843	18915	38.7	48843	100.0
ND	69299	0	0.0	66910	96.6
NE	76639	8500	11.1	76639	100.0
NH	8992	0	0.0	6891	76.6
NJ	7468	7468	100.0	7468	100.0
NM	121336	120	0.1	110469	91.0
NV	109895	26034	23.7	55818	50.8
NY	47379	12202	25.8	36271	76.6
OH	41004	10384	25.3	41004	100.0
OK	68656	4008	5.8	68656	100.0
OR	96187	3985	4.1	94738	98.5
PA	44892	18754	41.8	44892	100.0
RI	1054	99	9.4	1054	100.0
SC	30207	5242	17.4	30207	100.0
SD	75956	3091	4.1	75618	99.6
TN	41154	8114	19.7	41154	100.0
TX	262015	50591	19.3	209854	80.1
UT	82076	7926	9.7	74956	91.3
VA	39700	25695	64.7	39700	100.0
VT	9273	0	0.0	5288	57.0
WA	66512	6592	9.9	65889	99.1
WI	54424	10423	19.2	54424	100.0
WV	24124	5796	24.0	24124	100.0
WY	96988	53751	55.4	96958	100.0

* Area in Square Miles

TABLE 8 EMS CROSS-COUNTRY COVERAGE - LISTED IN DESCENDING ORDER OF PERCENTAGE CROSS-COUNTRY COVERAGE

STATE	REGION	LOCAL COVERAGE AREA*	LOCAL COVERAGE PERCENT	CROSS COUNTRY COVERAGE AREA*	CROSS COUNTRY COVERAGE PERCENT
AR	ASW	5264	9.9	53187	100.0
AZ	AWP	113510	100.0	113510	100.0
CA	AWP	156297	100.0	156297	100.0
CO	ANM	13258	12.8	103598	100.0
CT	ANE	4439	91.1	4872	100.0
DE	AEA	1561	80.8	1933	100.0
FL	ASO	42647	78.7	54157	100.0
IA	ACE	13354	23.9	55965	100.0
ID	ANM	24409	29.6	82413	100.0
IL	AGL	9943	17.9	55646	100.0
IN	AGL	12944	36.0	35936	100.0
KS	ACE	7559	9.2	81783	100.0
KY	ASO	13940	35.1	39674	100.0
LA	ASW	25090	56.4	44520	100.0
MA	ANE	4712	60.2	7826	100.0
MD	AEA	9838	100.0	9838	100.0
MN	AGL	5578	7.0	79548	100.0
MO	ACE	8476	12.3	68945	100.0
MS	ASO	11470	24.3	47234	100.0
NC	ASO	18915	38.7	48843	100.0
NE	ACE	8500	11.1	76639	100.0
NJ	AEA	7468	100.0	7468	100.0
OH	AGL	10384	25.3	41004	100.0
OK	ASW	4008	5.8	68656	100.0
PA	AEA	18754	41.8	44892	100.0
RI	ANE	99	9.4	1054	100.0
SC	ASO	5242	17.4	30207	100.0
TN	ASO	8114	19.7	41154	100.0
VA	AEA	25695	64.7	39700	100.0
WI	AGL	10423	19.2	54424	100.0
WV	AEA	5796	24.0	24124	100.0
WY	ANM	53751	55.4	96958	100.0
SD	AGL	3091	4.1	75618	99.6
AL	ASO	4637	9.1	50308	99.1
WA	ANM	6592	9.9	65889	99.1
OR	ANM	3985	4.1	94738	98.5
GA	ASO	23086	39.8	56298	97.0
ND	AGL	0	0.0	66910	96.6
UT	ANM	7926	9.7	74956	91.3
NM	ASW	120	0.1	110469	91.0
MT	ANM	97103	66.8	131491	90.4
MI	AGL	11181	19.6	48773	85.6
TX	ASW	50591	19.3	209854	80.1
NH	ANE	0	0.0	6891	76.6
NY	AEA	12202	25.8	36271	76.6
VT	ANE	0	0.0	5288	57.0
NV	AWP	26034	23.7	55818	50.8
AK	AAL	266349	46.7	266349	46.7
ME	ANE	0	0.0	1546	5.0
HI	AWP	0	0.0	0	0.0

* Area in Square Miles

TABLE 9 EMS LOCAL COVERAGE - LISTED IN DESCENDING ORDER OF PERCENTAGE LOCAL COVERAGE

STATE	REGION	LOCAL COVERAGE AREA*	LOCAL COVERAGE PERCENT	CROSS COUNTRY COVERAGE AREA*	CROSS COUNTRY COVERAGE PERCENT
AZ	AWP	113510	100.0	113510	100.0
CA	AWP	156297	100.0	156297	100.0
MD	AEA	9838	100.0	9838	100.0
NJ	AEA	7468	100.0	7468	100.0
CT	ANE	4439	91.1	4872	100.0
DE	AEA	1561	80.8	1933	100.0
FL	ASO	42647	78.7	54157	100.0
MT	ANM	97103	66.8	131491	90.4
VA	AEA	25695	64.7	39700	100.0
MA	ANE	4712	60.2	7826	100.0
LA	ASW	25090	56.4	44520	100.0
WY	ANM	53751	55.4	96958	100.0
AK	AAL	266349	46.7	266349	46.7
PA	AEA	18754	41.8	44892	100.0
GA	ASO	23086	39.8	56298	97.0
NC	ASO	18915	38.7	48843	100.0
IN	AGL	12944	36.0	35936	100.0
KY	ASO	13940	35.1	39674	100.0
ID	ANM	24409	29.6	82413	100.0
NY	AEA	12202	25.8	36271	76.6
OH	AGL	10384	25.3	41004	100.0
MS	ASO	11470	24.3	47234	100.0
WV	AEA	5796	24.0	24124	100.0
IA	ACE	13354	23.9	55965	100.0
NV	AWP	26034	23.7	55818	50.8
TN	ASO	8114	19.7	41154	100.0
MI	AGL	11181	19.6	48773	85.6
TX	ASW	50591	19.3	209854	80.1
WI	AGL	10423	19.2	54424	100.0
IL	AGL	9943	17.9	55646	100.0
SC	ASO	5242	17.4	30207	100.0
CO	ANM	13258	12.8	103598	100.0
MO	ACE	8476	12.3	68945	100.0
NE	ACE	8500	11.1	76639	100.0
AR	ASW	5264	9.9	53187	100.0
WA	ANM	6592	9.9	65889	99.1
UT	ANM	7926	9.7	74956	91.3
RI	ANE	99	9.4	1054	100.0
KS	ACE	7559	9.2	81783	100.0
AL	ASO	4637	9.1	50308	99.1
MN	AGL	5578	7.0	79548	100.0
OK	ASW	4008	5.8	68656	100.0
OR	ANM	3985	4.1	94738	98.5
SD	AGL	3091	4.1	75618	99.6
NM	ASW	120	0.1	110469	91.0
HI	AWP	0	0.0	0	0.0
ME	ANE	0	0.0	1546	5.0
ND	AGL	0	0.0	66910	96.6
NH	ANE	0	0.0	6891	76.6
VT	ANE	0	0.0	5288	57.0

* Area in Square Miles

missions, and the remaining 6 operators all had cross-country operating areas significantly larger than the rest of the operators in their respective FAA regions. There are two cross-country-only operators in the Great Lakes Region (minus the four public service operators). Their average coverage area is 23.0 percent larger than the regional average. In the Western-Pacific Region, one operator provides cross-country-only service with a service area 92.5 percent larger than the regional average. In the Southwest Region, three operators provide cross-country-only service with an average of their service areas 102.0 percent larger than the regional average. Thus, except for the operator with the mountainous operating area from the Northwest Mountain Region, the size of the service areas of the cross-country-only providers is larger than their regional averages. This would indicate that these operators probably concentrate on long-distance transports.

TABLE 10 AVERAGE SIZE OF COVERAGE AREAS FOR CONUS AND FAA REGIONS

Region	Number of Operators	Average Local Area*	Average Local Radius**	Number of Operators	Average Cross-Country Area*	Average Cross-Country Radius**
New England	3	4,161	36	3	44,299	119
Eastern	31	4,864	39	31	39,653	112
Southern	39	6,551	46	39	53,657	131
Great Lakes	29	2,888	30	35	74,215	154
Central	19	3,273	32	18	102,844	181
Southwest	22	3,948	35	25	76,667	156
Western-Pacific	23	18,448	77	24	36,720	102
Northwest Mountain	18	13,620	66	20	107,532	185
Alaskan	2	133,174	206	2	133,174	206
Total US	187	8,561	52	198	66,774	146
CONUS (48 States)	185	7,214	48	196	66,096	145

* (miles^2)
** (miles)

There are many possible reasons for this concentration; however, they are site specific and are not addressed for this report. However, through discussions with individual operators, the following reasons were given as factors that affect the size of operating areas: 1) low population density may lead to larger operational areas, since the service will receive calls from distant, rural hospitals with no other source for advanced medical care; 2) the presence of a fixed-wing EMS provider in the area may restrict the size of the EMS/H provider's operational area, since the fixed-wing provider can cover long distances faster and cheaper than a helicopter provider; 3) the limited availability and medical capability of ground ambulances may increase the size of the operating area, since some communities cannot spare an ambulance to make a 2 or 3 hour patient transport to a specialty treatment center while leaving the community without adequate EMS service during its absence; and 4) some hospitals support specialty centers, for example a neural center, and patients are typically brought in from large distances for treatment.

The first six local radius averages for CONUS regions listed in table 10 range from 30 to 46 miles, a difference of only 34.8 percent. These are the average radii for six of the eight CONUS regions. The other two regions, the Western-Pacific and the Northwest Mountain, have average local operating area radii of 77 and 66 miles, respectively. The reason their local average radii are so much larger can be seen in figure A-1, Local Operating Area Coverage for the Conterminous United States. In the Western Pacific Region, the public-service operators in both California and Arizona cover the entire state. In these states, the operational area was calculated as the state area divided by the number of helicopter bases used by the public-service operator. In the Northwest Mountain Region, there are 3 out of 19 operators that have unusually large local areas which skew the average radius to the high side of the CONUS average local radius of 52 miles. However, all of these average radii are easily within 1 hour's one-way flight time. The same first six cross-country radius averages for CONUS regions in table 10 range from 112 to 181 miles, a difference of 38.1 percent. Interestingly, the average radius for the Western-Pacific Region is less than the range of coverage radii for the other six CONUS regions, while the Northwest Mountain Region radius is larger than the range. The average cross-country radius for the Western-Pacific Region is smaller than the range because of the large number of public-service operator bases in California and Arizona. The average cross-country radius for the Northwest Mountain Region is larger than the average, possibly because it has large areas of low population density. The Central, Southwest, and Great Lakes Regions also have large areas of low population density and average cross-country radii at the high end of the range. The Eastern, Southern, and New England Regions have large areas of dense population and average cross-country radii at the low end of the range. The average cross-country radius for CONUS was 145 miles.

The Alaskan Region presents environmental conditions more severe than in the CONUS regions. In addition, it has a very low population density. This has led to few operators serving large operating areas. In fact, much like the CONUS operators from mountainous areas, the Alaskan operators do not seem to differentiate between local and cross-country operating areas, since both operators reported them to be the same. In addition, both Alaskan operators reported being collocated with affiliated fixed-wing operators that are used during instrument meterological conditions, icing conditions, and/or for the long-range transports. The average operating radius reported for Alaska was 206 miles.

3.5 WEATHER-AVAILABILITY

As defined in section 3.4, the term weather-availability was coined to describe the percentage of time that the weather is better than the operator's minimums. In order to determine the weather-availability in the areas where coverage is provided, the percentage of time that the operators cannot fly because of their weather minimums was averaged over each state. In areas where more than one operator provides service, the operator with the least restrictive weather minimums was chosen for the average, and the operator with the more restrictive weather minimums was left out of the state average. This was done because of the large degree of overlapping coverage in many areas of the country. Weather-availability was then calculated by subtracting the percent time operators could not fly due to weather from 100 percent.

Table 11 shows the weather availability in areas where service is provided in the FAA regions and in CONUS. With the exception of the Alaskan Region, which will be discussed separately, weather-availability steadily decreases from the day/local regime, to the day/cross-country regime, to the night/local regime, to the night/cross-country regime. For all four regimes, the New England Region has the lowest weather-availability, ranging from 91.2 percent in the day/local regime to 77.0 percent in the night/cross-country regime. The Western-Pacific Region has the highest weather-availability for local operations with 97.8 percent for day/local and 95.2 percent for night/local. The Northwest Mountain Region has the highest weather-availability for cross-country operations with 96.6 percent for day/cross-country and 94.4 percent for night/cross-country operations. The Alaskan Region has weather-availability percentages which are higher than any of the CONUS regions for all four regimes. However, the Alaskan data was calculated from only one operator's response in southern Alaska. No data was available from the northern part of the state. Therefore, no trends should be assumed for Alaska from this one data point.

TABLE 11 WEATHER-AVAILABILITY IN AREAS WITH COVERAGE BY FAA REGION (Percent)

Region	Day/Local	Day/Cross-Country	Night/Local	Night/Cross-Country
ASO	96.2	93.3	92.3	88.9
AWP	97.8	96.2	95.2	93.3
AAL	98.4	97.4	98.4	93.6
ANM	97.1	96.6	94.9	94.4
ANE	91.2	86.6	86.1	77.0
AEA	93.4	90.3	88.5	83.7
AGL	94.9	91.5	89.2	85.7
ACE	96.8	94.5	93.1	89.7
ASW	96.6	96.0	93.6	93.0
CON	96.6	94.5	93.4	90.6

The weather-availability in areas where coverage is provided is presented in table 12. Tables 13-16 present the data ordered by weather-availability in the day/local, day/cross-country, night/local, and night/cross-country regimes. As would be expected, since the weather-availability is a reflection of the weather, the same states tend to be at either the high end or at the low end of the range. For example, Arizona and New Mexico, with their exceptionally good flying weather, have the highest weather-availability for all four regimes. Rhode Island and Massachusetts, on the other hand, have the lowest weather-availability in the daytime regimes, while Rhode Island and West Virginia have the lowest weather-availability in the night regimes. The switch from Massachusetts to West Virginia is probably due to the conservative weather minimums adopted by most operators for operations at night over mountainous areas.

TABLE 12 WEATHER-AVAILABILITY STATE (PERCENT)

REGION	STATE	DAY/ LOCAL	DAY/ CROSS COUNTRY	NIGHT/ LOCAL	NIGHT/ CROSS COUNTRY
AAL	AK	98.4	97.4	98.4	93.6
ASO	AL	96.4	93.2	94.1	89.6
ASW	AR	97.3	94.5	94.5	92.2
AWP	AZ	99.7	99.4	99.4	99.2
AWP	CA	96.6	93.7	92.2	88.5
ANM	CO	98.1	96.4	96.6	95.1
ANE	CT	92.6	87.5	87.5	76.7
AEA	DE	97.6	96.7	94.7	93.3
ASO	FL	96.9	95.1	93.8	91.7
ASO	GA	94.9	92.0	89.8	87.0
ACE	IA	96.8	92.9	91.4	88.3
ANM	ID	98.7	98.1	95.9	95.3
AGL	IL	95.5	93.7	91.7	89.1
AGL	IN	94.7	91.0	87.2	90.2
ACE	KS	95.1	93.9	92.4	88.1
ASO	KY	98.7	95.7	95.7	92.3
ASW	LA	95.5	94.2	93.8	92.0
ANE	MA	89.9	84.8	84.8	75.5
AEA	MD	92.8	92.8	89.5	89.5
ANE	ME	0.0	87.5	0.0	79.4
AGL	MI	93.7	90.6	87.4	83.2
AGL	MN	95.0	91.7	89.7	86.4
ACE	MO	96.6	92.8	92.2	87.4
ASO	MS	96.8	93.1	91.6	87.8
ANM	MT	96.2	95.7	94.2	93.8
ASO	NC	94.0	90.4	88.8	83.9
AGL	ND	92.6	92.6	86.1	86.1
ACE	NE	98.7	97.7	97.2	94.6
ANE	NH	0.0	87.5	0.0	79.4
AEA	NJ	91.2	91.2	86.8	86.8
ASW	NM	99.5	98.9	98.9	98.1
AWP	NV	97.2	96.9	95.1	94.6
AEA	NY	91.9	87.5	85.0	79.2
AGL	OH	95.7	91.7	90.5	85.9
ASW	OK	97.0	95.6	93.6	92.2
ANM	OR	97.9	97.5	97.5	94.8
AEA	PA	93.6	90.2	88.5	84.7
ANE	RI	88.3	84.8	82.1	72.8
ASO	SC	94.6	92.5	92.5	89.9
AGL	SD	95.2	89.9	89.9	82.2
ASO	TN	97.0	94.7	93.4	90.5
ASW	TX	97.1	95.3	93.4	90.9
ANM	UT	97.9	96.5	96.5	95.3
AEA	VA	94.8	94.5	90.5	90.0
ANE	VT	0.0	87.5	0.0	76.7
ANM	WA	95.1	94.5	93.3	90.2
AGL	WI	94.8	91.2	89.2	85.1
AEA	WV	92.7	85.9	85.9	74.0
ANM	WY	97.7	97.7	95.2	95.2

TABLE 13 WEATHER-AVAILABILITY DAY/LOCAL (PERCENT)

REGION	STATE	DAY/ LOCAL	DAY/ CROSS COUNTRY	NIGHT/ LOCAL	NIGHT/ CROSS COUNTRY
AWP	AZ	99.7	99.4	99.4	99.2
ASW	NM	99.5	98.9	98.9	98.1
ANM	ID	98.7	98.1	95.9	95.3
ACE	NE	98.7	97.7	97.2	94.6
ASO	KY	98.7	95.7	95.7	92.3
AAL	AK	98.4	97.4	98.4	93.6
ANM	CO	98.1	96.4	96.6	95.1
ANM	UT	97.9	96.5	96.5	95.3
ANM	OR	97.9	97.5	97.5	94.8
ANM	WY	97.7	97.7	95.2	95.2
AEA	DE	97.6	96.7	94.7	93.3
ASW	AR	97.3	94.5	94.5	92.2
AWP	NV	97.2	96.9	95.1	94.6
ASW	TX	97.1	95.3	93.4	90.9
ASO	TN	97.0	94.7	93.4	90.5
ASW	OK	97.0	95.6	93.6	92.2
ASO	FL	96.9	95.1	93.8	91.7
ACE	IA	96.8	92.9	91.4	88.3
ASO	MS	96.8	93.1	91.6	87.8
AWP	CA	96.6	93.7	92.2	88.5
ACE	MO	96.6	92.8	92.2	87.4
ASO	AL	96.4	93.2	94.1	89.6
ANM	MT	96.2	95.7	94.2	93.8
AGL	OH	95.7	91.7	90.5	85.9
AGL	IL	95.5	93.7	91.7	89.1
ASW	LA	95.5	94.2	93.8	92.0
AGL	SD	95.2	89.9	89.9	82.2
ACE	KS	95.1	93.9	92.4	88.1
ANM	WA	95.1	94.5	93.3	90.2
AGL	MN	95.0	91.7	89.7	86.4
ASO	GA	94.9	92.0	89.8	87.0
AGL	WI	94.8	91.2	89.2	85.1
AEA	VA	94.8	94.5	90.5	90.0
AGL	IN	94.7	91.0	87.2	90.2
ASO	SC	94.6	92.5	92.5	89.9
ASO	NC	94.0	90.4	88.8	83.9
AGL	MI	93.7	90.6	87.4	83.2
AEA	PA	93.6	90.2	88.5	84.7
AEA	MD	92.8	92.8	89.5	89.5
AEA	WV	92.7	85.9	85.9	74.0
AGL	ND	92.6	92.6	86.1	86.1
ANE	CT	92.6	87.5	87.5	76.7
AEA	NY	91.9	87.5	85.0	79.2
AEA	NJ	91.2	91.2	86.8	86.8
ANE	MA	89.9	84.8	84.8	75.5
ANE	RI	88.3	84.8	82.1	72.8
ANE	NH	0.0	87.5	0.0	79.4
ANE	VT	0.0	87.5	0.0	76.7
ANE	ME	0.0	87.5	0.0	79.4

TABLE 14 WEATHER-AVAILABILITY DAY/CROSS-COUNTRY (PERCENT)

REGION	STATE	DAY/ LOCAL	DAY/ CROSS COUNTRY	NIGHT/ LOCAL	NIGHT/ CROSS COUNTRY
AWP	AZ	99.7	99.4	99.4	99.2
ASW	NM	99.5	98.9	98.9	98.1
ANM	ID	98.7	98.1	95.9	95.3
ACE	NE	98.7	97.7	97.2	94.6
ANM	WY	97.7	97.7	95.2	95.2
ANM	OR	97.9	97.5	97.5	94.8
AAL	AK	98.4	97.4	98.4	93.6
AWP	NV	97.2	96.9	95.1	94.6
AEA	DE	97.6	96.7	94.7	93.3
ANM	UT	97.9	96.5	96.5	95.3
ANM	CO	98.1	96.4	96.6	95.1
ANM	MT	96.2	95.7	94.2	93.8
ASO	KY	98.7	95.7	95.7	92.3
ASW	OK	97.0	95.6	93.6	92.2
ASW	TX	97.1	95.3	93.4	90.9
ASO	FL	96.9	95.1	93.8	91.7
ASO	TN	97.0	94.7	93.4	90.5
AEA	VA	94.8	94.5	90.5	90.0
ASW	AR	97.3	94.5	94.5	92.2
ANM	WA	95.1	94.5	93.3	90.2
ASW	LA	95.5	94.2	93.8	92.0
ACE	KS	95.1	93.9	92.4	88.1
AWP	CA	96.6	93.7	92.2	88.5
AGL	IL	95.5	93.7	91.7	89.1
ASO	AL	96.4	93.2	94.1	89.6
ASO	MS	96.8	93.1	91.6	87.8
ACE	IA	96.8	92.9	91.4	88.3
AEA	MD	92.8	92.8	89.5	89.5
ACE	MO	96.6	92.8	92.2	87.4
AGL	ND	92.6	92.6	86.1	86.1
ASO	SC	94.6	92.5	92.5	89.9
ASO	GA	94.9	92.0	89.8	87.0
AGL	OH	95.7	91.7	90.5	85.9
AGL	MN	95.0	91.7	89.7	86.4
AEA	NJ	91.2	91.2	86.8	86.8
AGL	WI	94.8	91.2	89.2	85.1
AGL	IN	94.7	91.0	87.2	90.2
AGL	MI	93.7	90.6	87.4	83.2
ASO	NC	94.0	90.4	88.8	83.9
AEA	PA	93.6	90.2	88.5	84.7
AGL	SD	95.2	89.9	89.9	82.2
AEA	NY	91.9	87.5	85.0	79.2
ANE	CT	92.6	87.5	87.5	76.7
ANE	VT	0.0	87.5	0.0	76.7
ANE	NH	0.0	87.5	0.0	79.4
ANE	ME	0.0	87.5	0.0	79.4
AEA	WV	92.7	85.9	85.9	74.0
ANE	RI	88.3	84.8	82.1	72.8
ANE	MA	89.9	84.8	84.8	75.5

TABLE 15 WEATHER-AVAILABILITY NIGHT/LOCAL (PERCENT)

REGION	STATE	DAY/ LOCAL	DAY/ CROSS COUNTRY	NIGHT/ LOCAL	NIGHT/ CROSS COUNTRY
AWP	AZ	99.7	99.4	99.4	99.2
ASW	NM	99.5	98.9	98.9	98.1
AAL	AK	98.4	97.4	98.4	93.6
ANM	OR	97.9	97.5	97.5	94.8
ACE	NE	98.7	97.7	97.2	94.6
ANM	CO	98.1	96.4	96.6	95.1
ANM	UT	97.9	96.5	96.5	95.3
ANM	ID	98.7	98.1	95.9	95.3
ASO	KY	98.7	95.7	95.7	92.3
ANM	WY	97.7	97.7	95.2	95.2
AWP	NV	97.2	96.9	95.1	94.6
AEA	DE	97.6	96.7	94.7	93.3
ASW	AR	97.3	94.5	94.5	92.2
ANM	MT	96.2	95.7	94.2	93.8
ASO	AL	96.4	93.2	94.1	89.6
ASO	FL	96.9	95.1	93.8	91.7
ASW	LA	95.5	94.2	93.8	92.0
ASW	OK	97.0	95.6	93.6	92.2
ASO	TN	97.0	94.7	93.4	90.5
ASW	TX	97.1	95.3	93.4	90.9
ANM	WA	95.1	94.5	93.3	90.2
ASO	SC	94.6	92.5	92.5	89.9
ACE	KS	95.1	93.9	92.4	88.1
AWP	CA	96.6	93.7	92.2	88.5
ACE	MO	96.6	92.8	92.2	87.4
AGL	IL	95.5	93.7	91.7	89.1
ASO	MS	96.8	93.1	91.6	87.8
ACE	IA	96.8	92.9	91.4	88.3
AEA	VA	94.8	94.5	90.5	90.0
AGL	OH	95.7	91.7	90.5	85.9
AGL	SD	95.2	89.9	89.9	82.2
ASO	GA	94.9	92.0	89.8	87.0
AGL	MN	95.0	91.7	89.7	86.4
AEA	MD	92.8	92.8	89.5	89.5
AGL	WI	94.8	91.2	89.2	85.1
ASO	NC	94.0	90.4	88.8	83.9
AEA	PA	93.6	90.2	88.5	84.7
ANE	CT	92.6	87.5	87.5	76.7
AGL	MI	93.7	90.6	87.4	83.2
AGL	IN	94.7	91.0	87.2	90.2
AEA	NJ	91.2	91.2	86.8	86.8
AGL	ND	92.6	92.6	86.1	86.1
AEA	WV	92.7	85.9	85.9	74.0
AEA	NY	91.9	87.5	85.0	79.2
ANE	MA	89.9	84.8	84.8	75.5
ANE	RI	88.3	84.8	82.1	72.8
ANE	VT	0.0	87.5	0.0	76.7
ANE	NH	0.0	87.5	0.0	79.4
ANE	ME	0.0	87.5	0.0	79.4

TABLE 16 WEATHER-AVAILABILITY NIGHT/CROSS-COUNTRY (PERCENT)

REGION	STATE	DAY/ LOCAL	DAY/ CROSS COUNTRY	NIGHT/ LOCAL	NIGHT/ CROSS COUNTRY
AWP	AZ	99.7	99.4	99.4	99.2
ASW	NM	99.5	98.9	98.9	98.1
ANM	UT	97.9	96.5	96.5	95.3
ANM	ID	98.7	98.1	95.9	95.3
ANM	WY	97.7	97.7	95.2	95.2
ANM	CO	98.1	96.4	96.6	95.1
ANM	OR	97.9	97.5	97.5	94.8
AWP	NV	97.2	96.9	95.1	94.6
ACE	NE	98.7	97.7	97.2	94.6
ANM	MT	96.2	95.7	94.2	93.8
AAL	AK	98.4	97.4	98.4	93.6
AEA	DE	97.6	96.7	94.7	93.3
ASO	KY	98.7	95.7	95.7	92.3
ASW	AR	97.3	94.5	94.5	92.2
ASW	OK	97.0	95.6	93.6	92.2
ASW	LA	95.5	94.2	93.8	92.0
ASO	FL	96.9	95.1	93.8	91.7
ASW	TX	97.1	95.3	93.4	90.9
ASO	TN	97.0	94.7	93.4	90.5
AGL	IN	94.7	91.0	87.2	90.2
ANM	WA	95.1	94.5	93.3	90.2
AEA	VA	94.8	94.5	90.5	90.0
ASO	SC	94.6	92.5	92.5	89.9
ASO	AL	96.4	93.2	94.1	89.6
AEA	MD	92.8	92.8	89.5	89.5
AGL	IL	95.5	93.7	91.7	89.1
AWP	CA	96.6	93.7	92.2	88.5
ACE	IA	96.8	92.9	91.4	88.3
ACE	KS	95.1	93.9	92.4	88.1
ASO	MS	96.8	93.1	91.6	87.3
ACE	MO	96.6	92.8	92.2	87.4
ASO	GA	94.9	92.0	89.8	87.0
AEA	NJ	91.2	91.2	86.8	86.8
AGL	MN	95.0	91.7	89.7	86.4
AGL	ND	92.6	92.6	86.1	86.1
AGL	OH	95.7	91.7	90.5	85.9
AGL	WI	94.8	91.2	89.2	85.1
AEA	PA	93.6	90.2	88.5	84.7
ASO	NC	94.0	90.4	88.8	83.9
AGL	MI	93.7	90.6	87.4	83.2
AGL	SD	95.2	89.9	89.9	82.2
ANE	ME	0.0	87.5	0.0	79.4
ANE	NH	0.0	87.5	0.0	79.4
AEA	NY	91.9	87.5	85.0	79.2
ANE	VT	0.0	87.5	0.0	76.7
ANE	CT	92.6	87.5	87.5	76.7
ANE	MA	89.9	84.8	84.8	75.5
AEA	WV	92.7	85.9	85.9	74.0
ANE	RI	88.3	84.8	82.1	72.8

3.6 MULTIPLE WEATHER MINIMUMS

An unexpected finding from the weather minimums analysis is the effect that multiple weather minimums can have on operations in marginal weather. By allowing lower ceiling limits in exchange for greater visibility requirements, all of the operators using multiple minimums were able to increase the percentage of time they can fly. Figure 13 graphically illustrates the principle of trading off ceiling for visibility. With minimums of 1,000 feet and 3 miles, a pilot has a 5.35 cubic mile volume of airspace in which to operate. Assuming the helicopter is traveling 120 miles per hour, this gives the pilot 1.5 minutes of reaction time. On the other hand, minimums of 800 feet and 5 miles give the pilot 11.90 cubic miles of airspace and 2.5 minutes of reaction time. Six operators with multiple minimums were chosen at random and evaluated. It was found that multiple minimums reduced the percentage of time an operator could not fly by from 6 to 20 percent, depending on the geographic location and its associated weather. The percentage of time that the same six operators could not fly without the multiple minimums ranged from 2.4 to 12.0 percent. Therefore, multiple minimums allowed the operators to fly an additional 0.2 percent to 1.8 percent of the time.

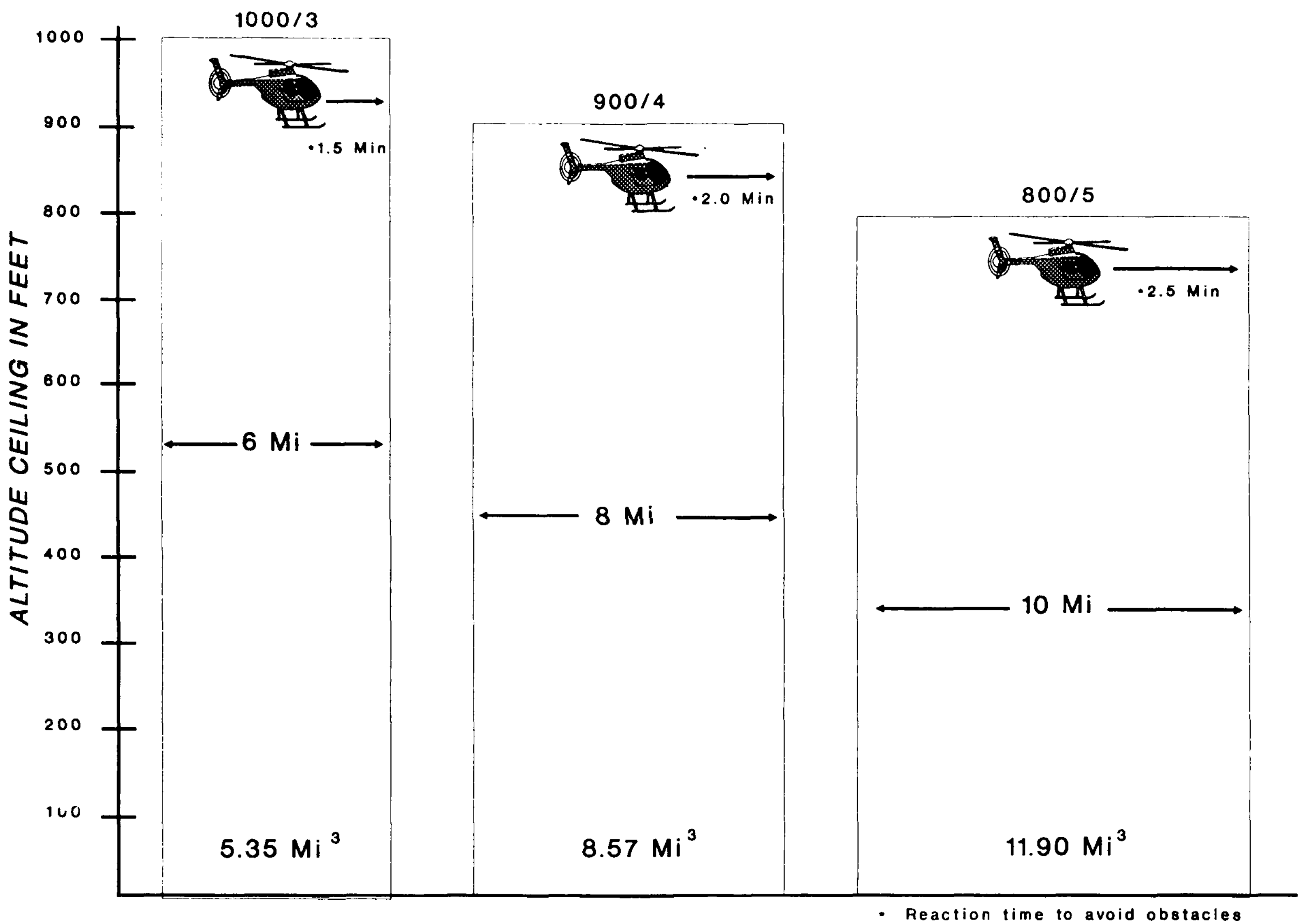


FIGURE 13 FLOATING WEATHER MINIMUMS

4.0 SUMMARY

The data collected in this study supports several findings. First, on the average most EMS/H operators have voluntarily chosen higher minimums than the minimums suggested in AC 135-14. Second, the proposed changes to AC 135-14 are less restrictive than most EMS/H operators' current night minimums and more restrictive than their day minimums. For both day/local and day/cross country conditions, the operators' average ceiling minimum is approximately 200 feet lower than the proposed AC 135-14 minimums. Also, for both night/local and night/cross country conditions, the operators' average visibility minimum is approximately 0.5 miles greater than the proposed AC 135-14 minimum.

Coverage maps that show the operational areas of EMS/H operators for both local and cross-country operation are provided in appendix A. Coverage maps are provided for CONUS, each FAA region, and each state. Approximately 30.6 percent of CONUS is covered by local EMS/H service, and 93.3 percent of CONUS is covered by cross-country EMS/H service. The average size of a local operational area in CONUS is 8,561 square miles, which equates to a 52 mile radius. The average size of a cross-country operational area in CONUS is 66,096 square miles, which equates to a 145 mile radius. The weather-availability in CONUS areas with EMS/H coverage ranges from 96.6 percent in the day/local regime to 90.6 percent in the night/cross-country regime.

LIST OF ACRONYMS

AC	Advisory Circular
ASF	Airport Specific File
ATC	Air Traffic Control
CFR	Code of Federal Regulations
CMSI	Climatic Mission Success Indicators
CONUS	Contiguous United States (48 States)
EMS/H	Emergency Medical Services/Helicopter
FAA	Federal Aviation Administration
FSS	Flight Service Station
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
MAST	Military Assistance to Safety and Traffic
MRA	Minimum Reception Altitude
NAWD	National Average Weather Data
NM	Nautical Mile
SVFR	Special Visual Flight Rules
VFR	Visual Flight Rules
VOR	Very High Frequency Omnidirectional Range

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2. Martin, Donald E. and Myers, Eloise, Climatic Models That Will Provide Timely Mission Success Indicators for Planning and Supporting Weather Sensitive Operations, AFGL-TR-78-0308, December 1978.

3. Wong, Emily P., Development of Revised and Expanded Airport Specific File Data for the Airport Criteria Data System, FAA-APO-86-8, DTFA01-84-01020, December 1985.

4. Emergency Medical Services/Helicopter (EMS/H), October 1988.

5. Rotorcraft Low Altitude CNS Cost/Benefit Analysis; Operations Analysis, DOT/FAA/DS-89/9, (date).

APPENDIX A
EMS/H OPERATIONAL AREAS

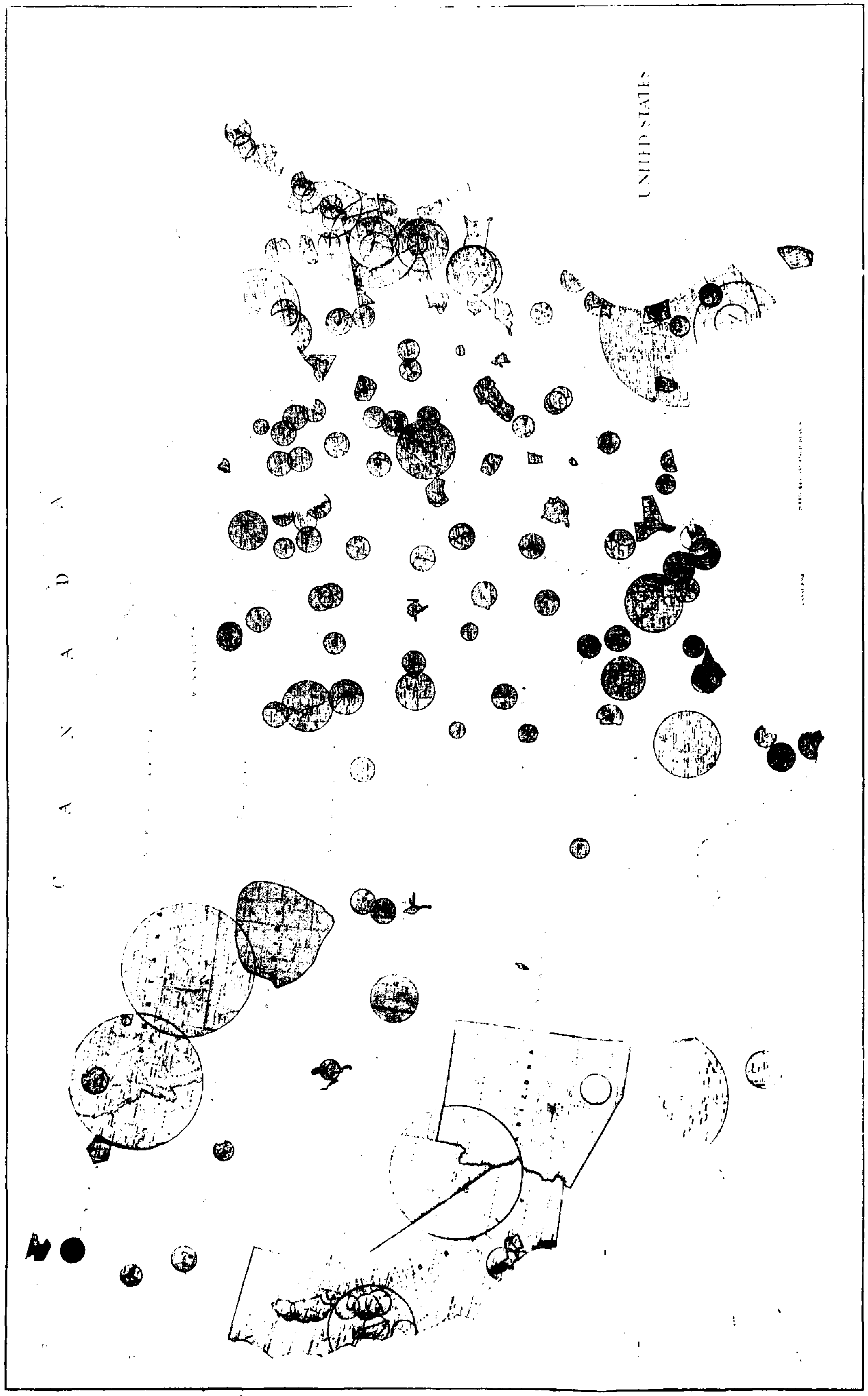


FIGURE A-1 LOCAL OPERATING AREA COVERAGE FOR THE CONTERMINOUS UNITED STATES

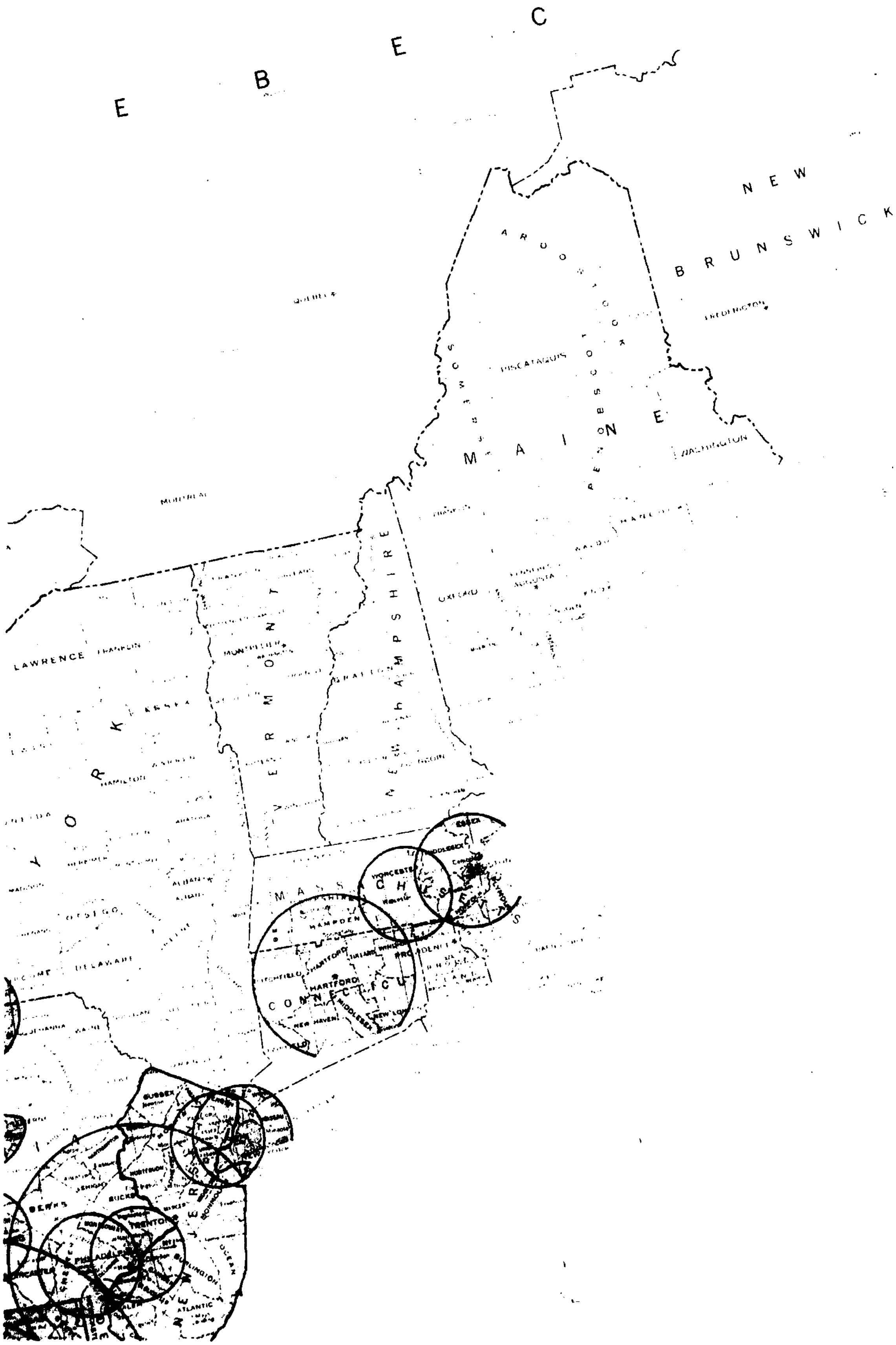


FIGURE A-2 LOCAL OPERATING AREA COVERAGE FOR THE NEW ENGLAND REGION

FIGURE A-3 LOCAL OPERATING AREA COVERAGE FOR THE EASTERN REGION

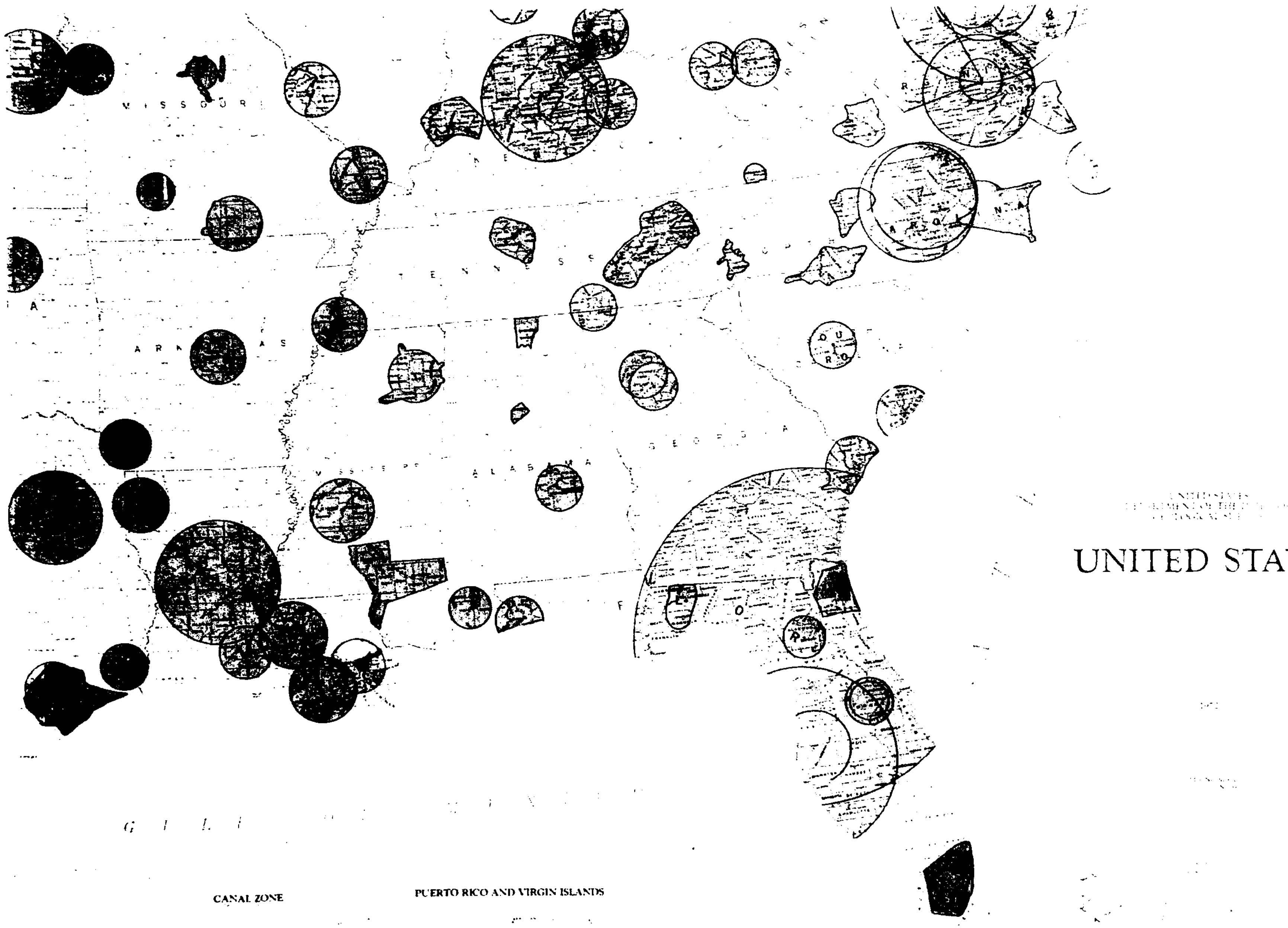


FIGURE A-4 LOCAL OPERATING AREA COVERAGE FOR THE SOUTHERN REGION

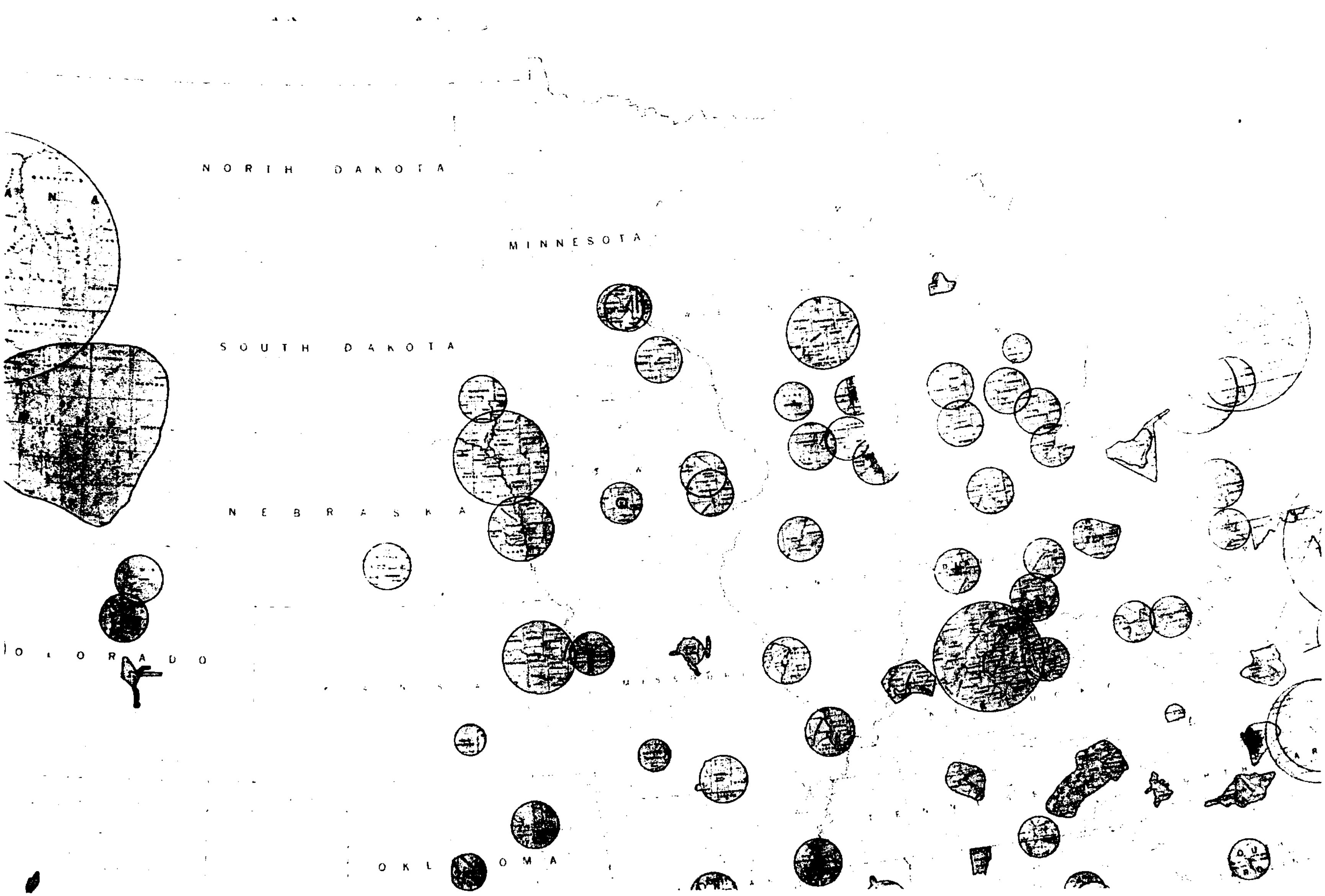


FIGURE A-5 LOCAL OPERATING AREA COVERAGE FOR THE GREAT LAKES REGION

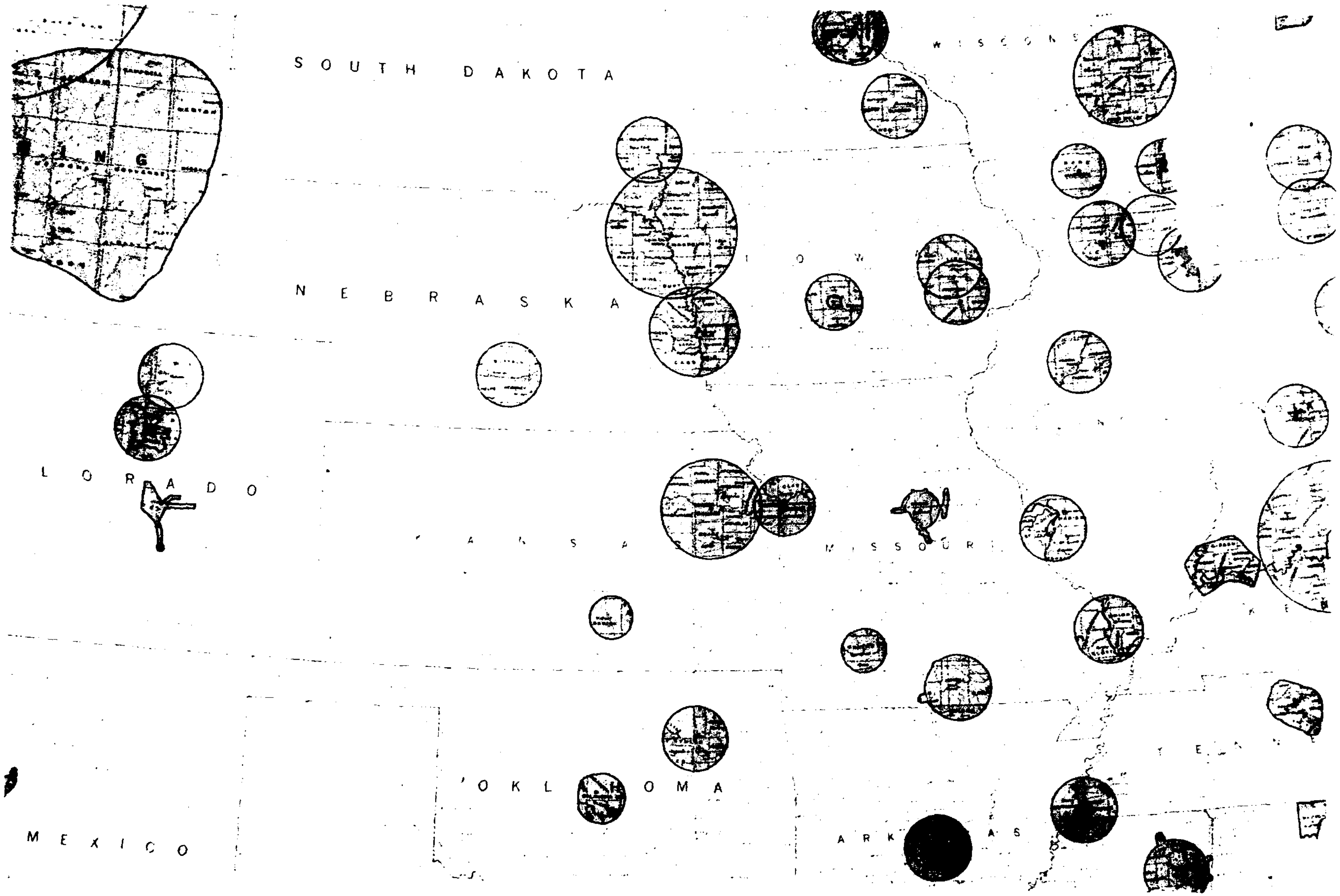


FIGURE A-6 LOCAL OPERATING AREA COVERAGE FOR THE CENTRAL REGION

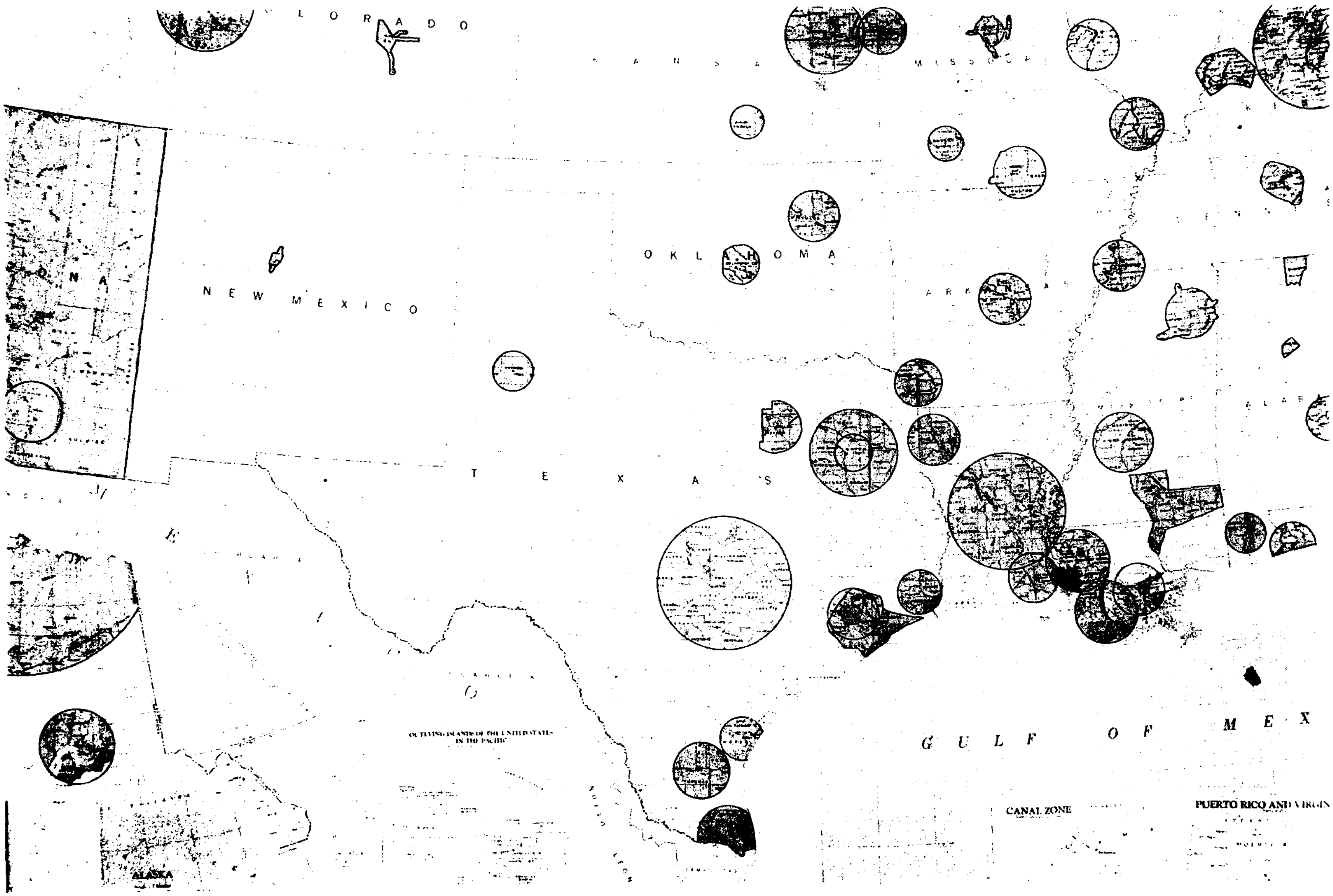


FIGURE A-7 LOCAL OPERATING AREA COVERAGE FOR THE SOUTHWEST REGION

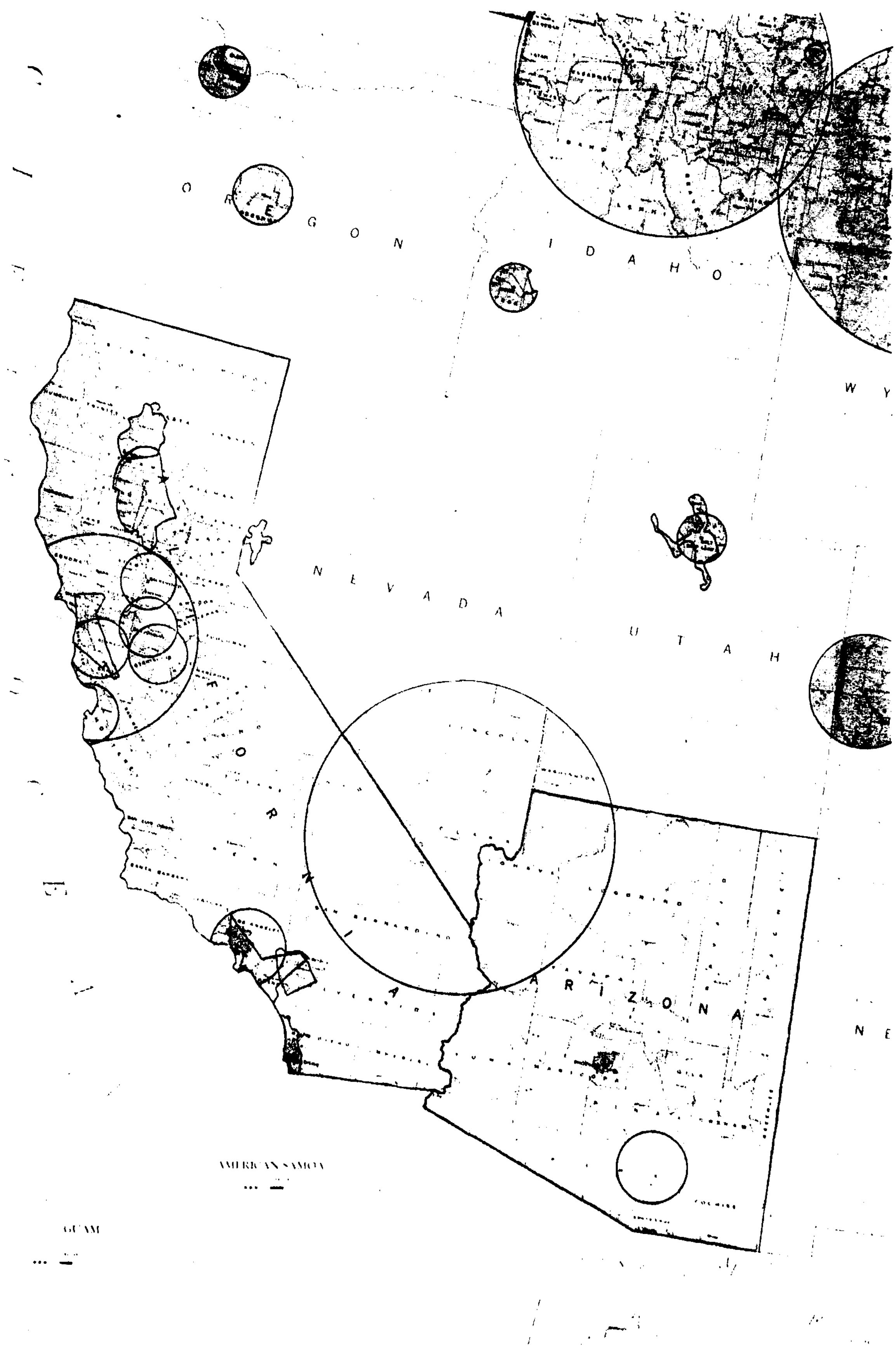


FIGURE A-8 LOCAL OPERATING AREA COVERAGE FOR THE WESTERN PACIFIC REGION

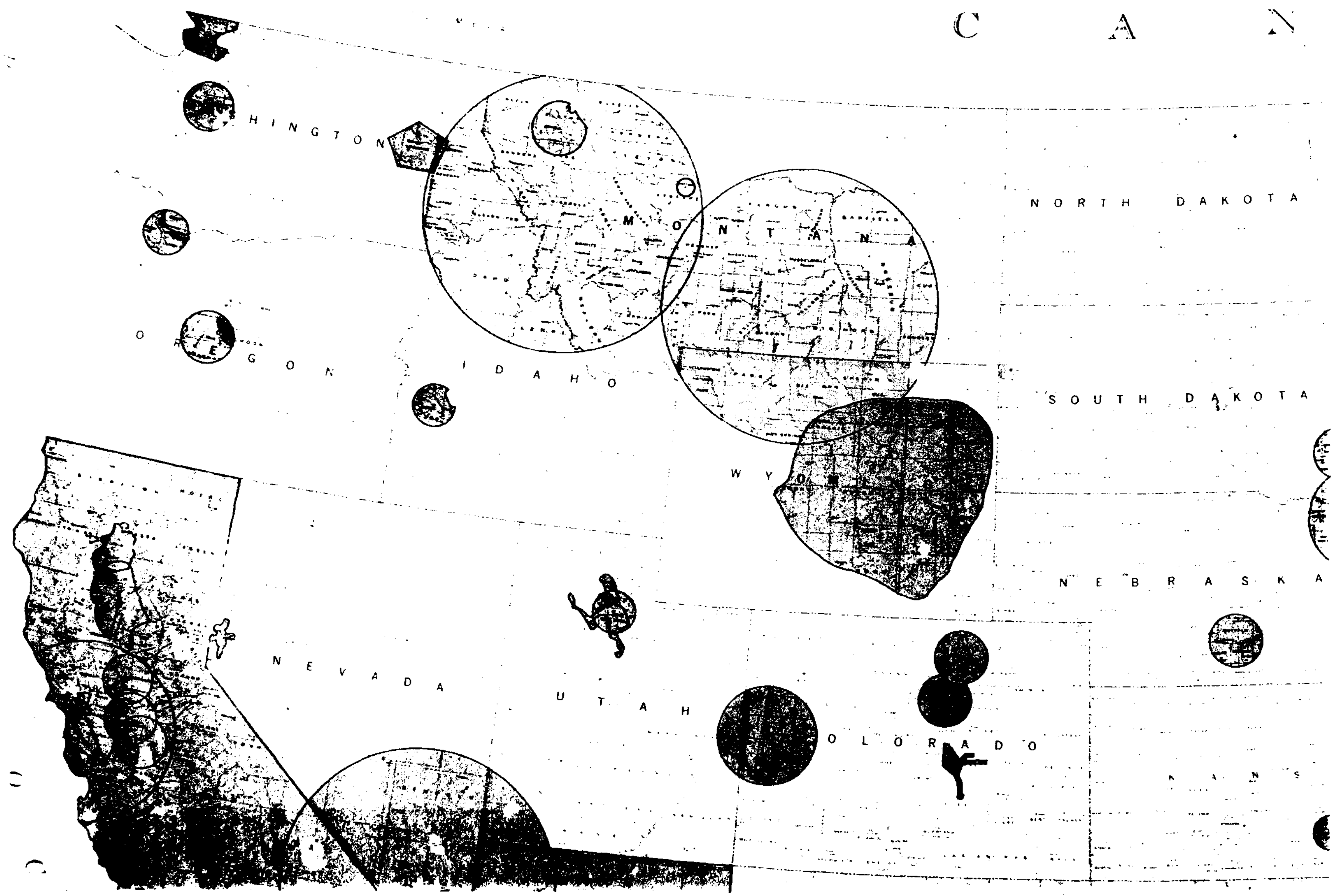


FIGURE A-9 LOCAL OPERATING AREA COVERAGE FOR THE NORTHWEST MOUNTAIN REGION

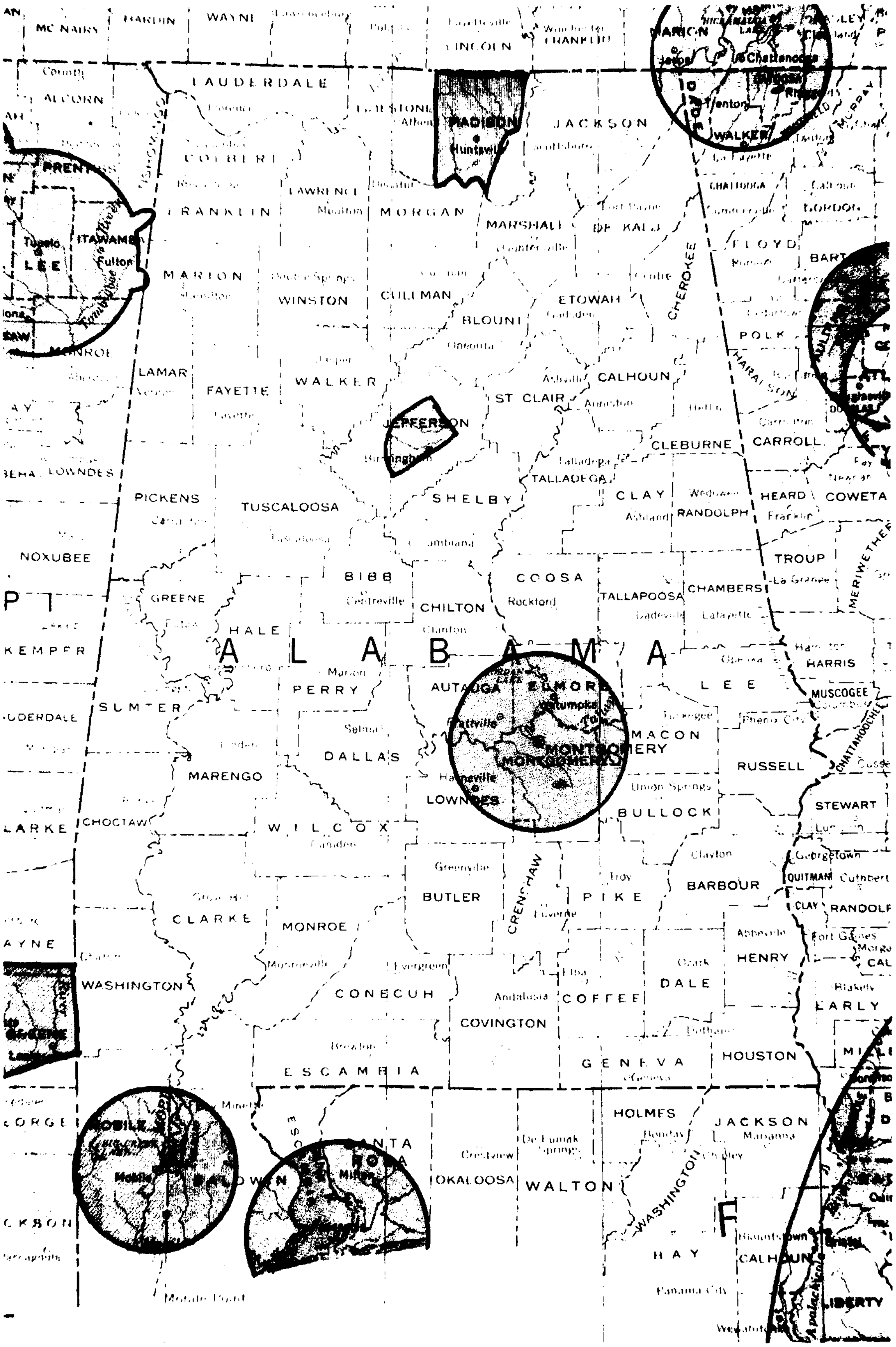


FIGURE A-10 LOCAL OPERATING AREA COVERAGE FOR ALABAMA

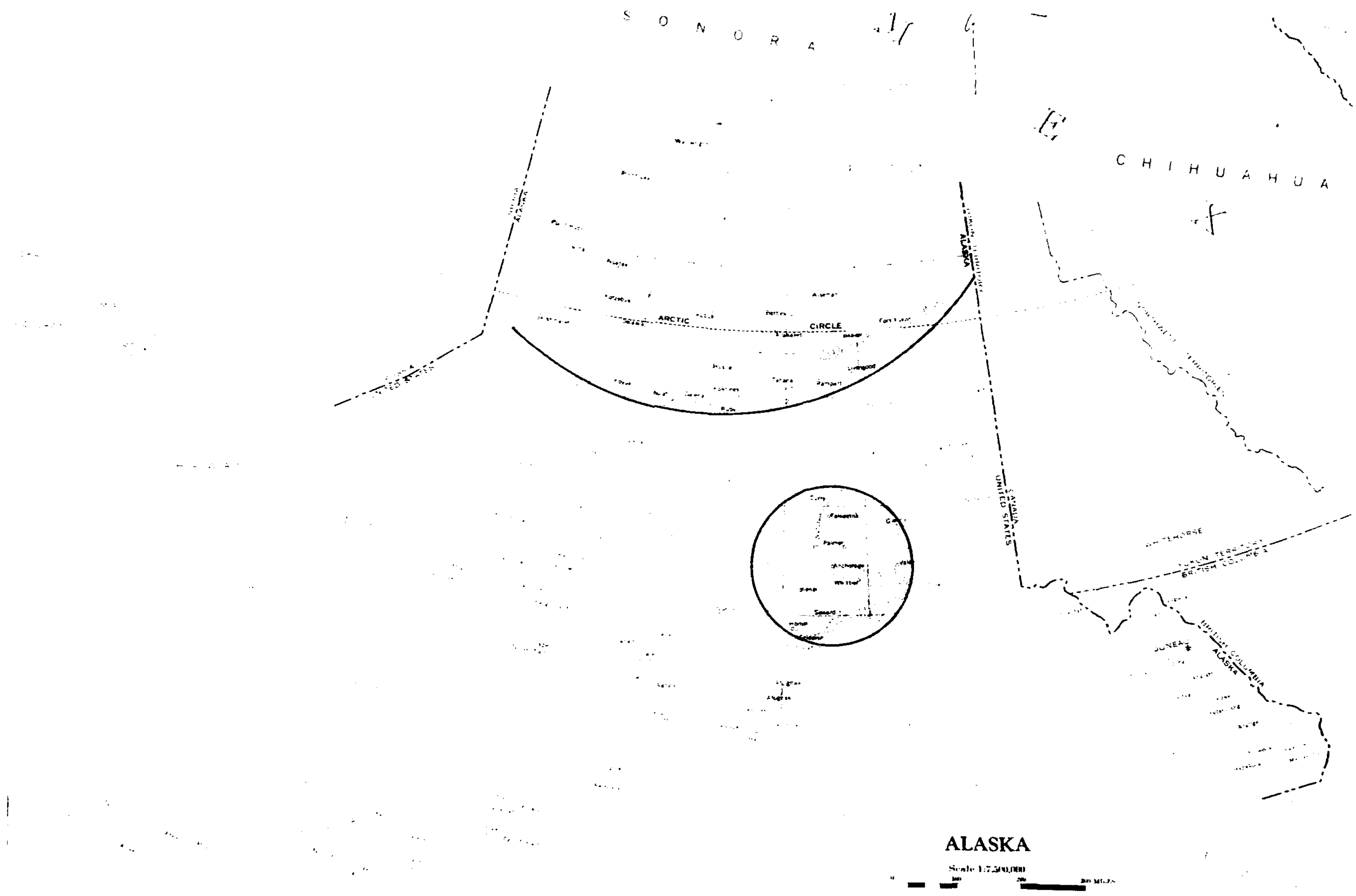


FIGURE A-11 LOCAL OPERATING AREA COVERAGE FOR ALASKA

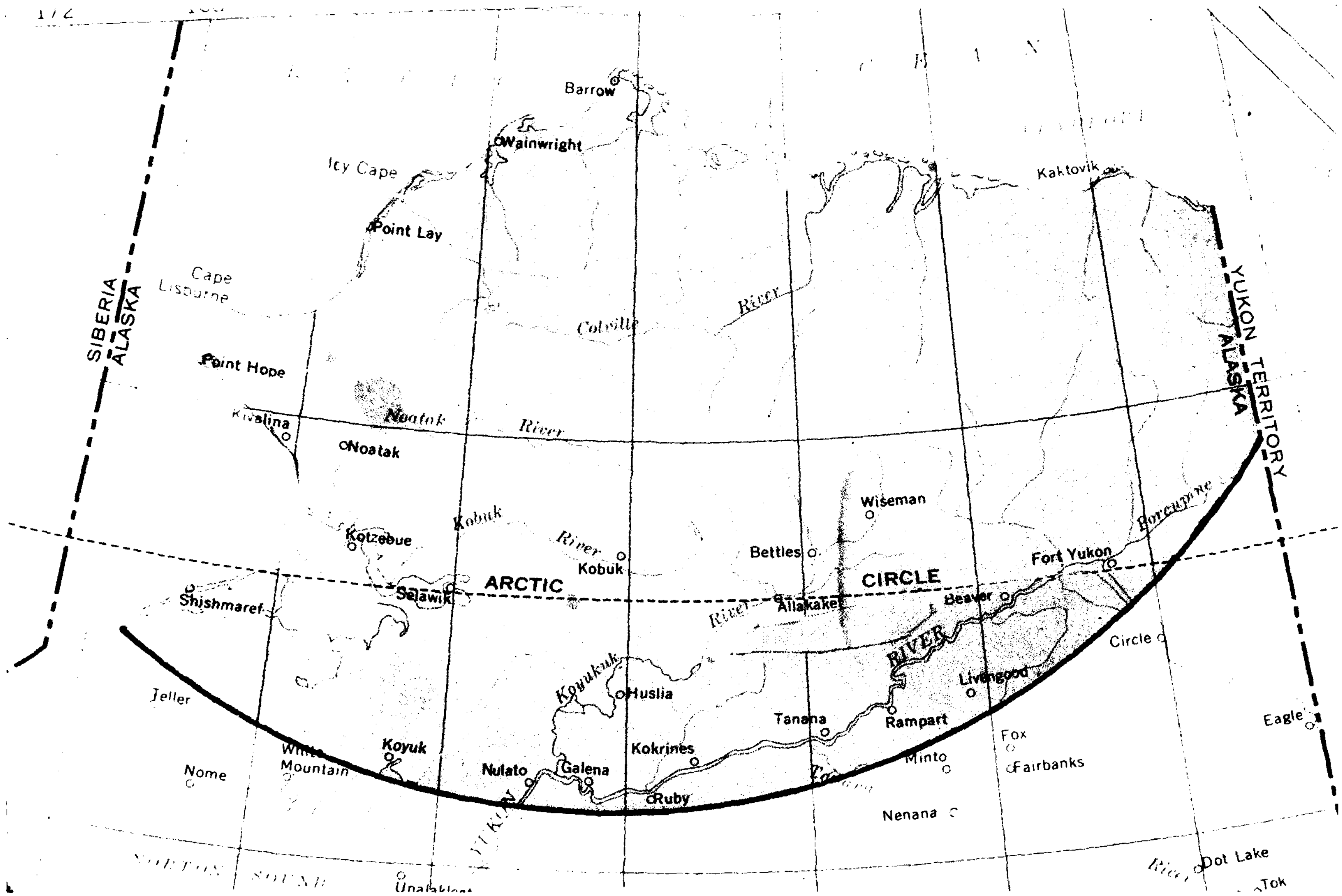


FIGURE A-12 LOCAL OPERATING AREA COVERAGE FOR NORTHERN ALASKA

FIGURE A-13 LOCAL OPERATING AREA COVERAGE FOR SOUTHERN ALASKA

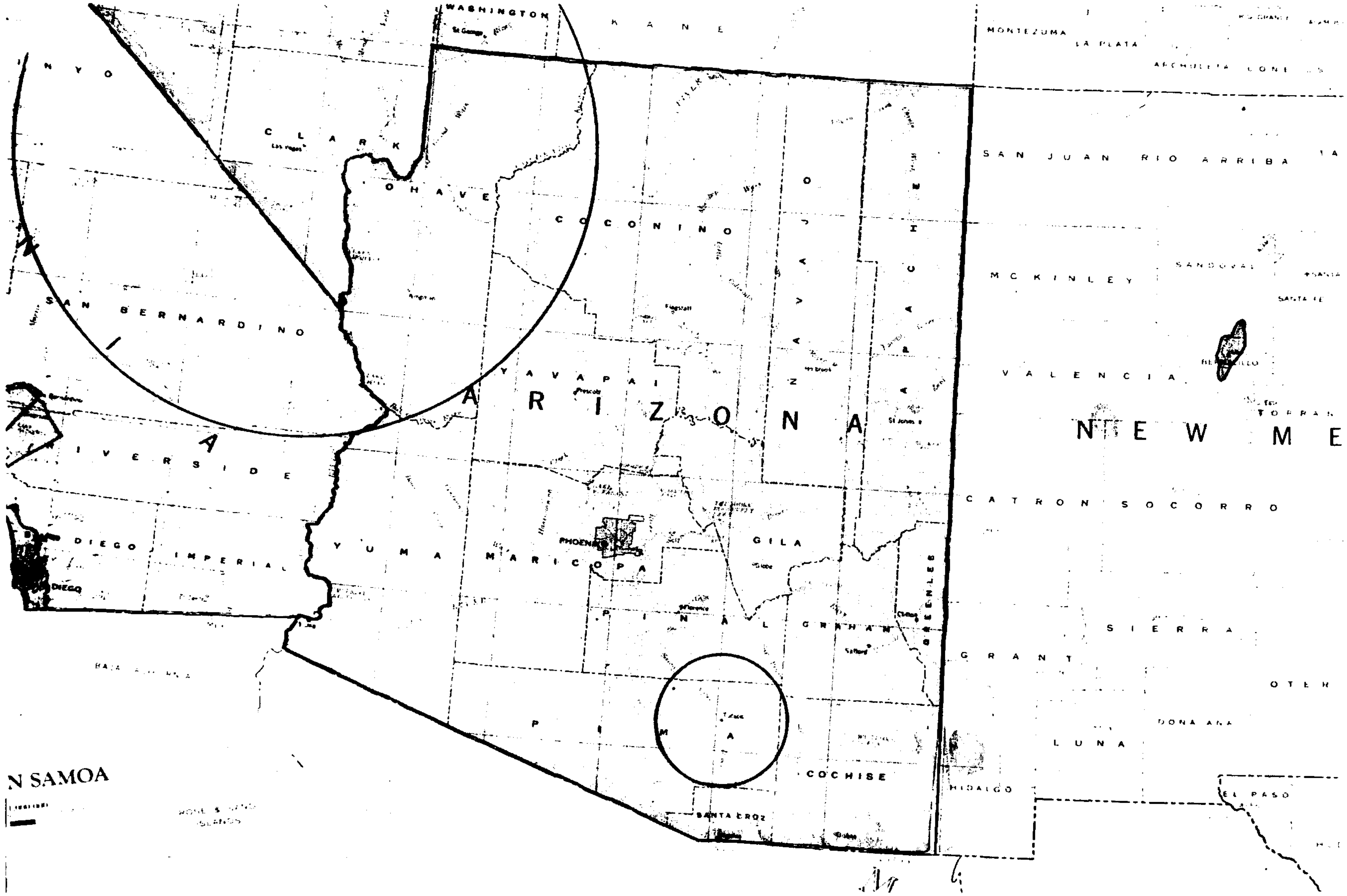


FIGURE A-14 LOCAL OPERATING AREA COVERAGE FOR ARIZONA

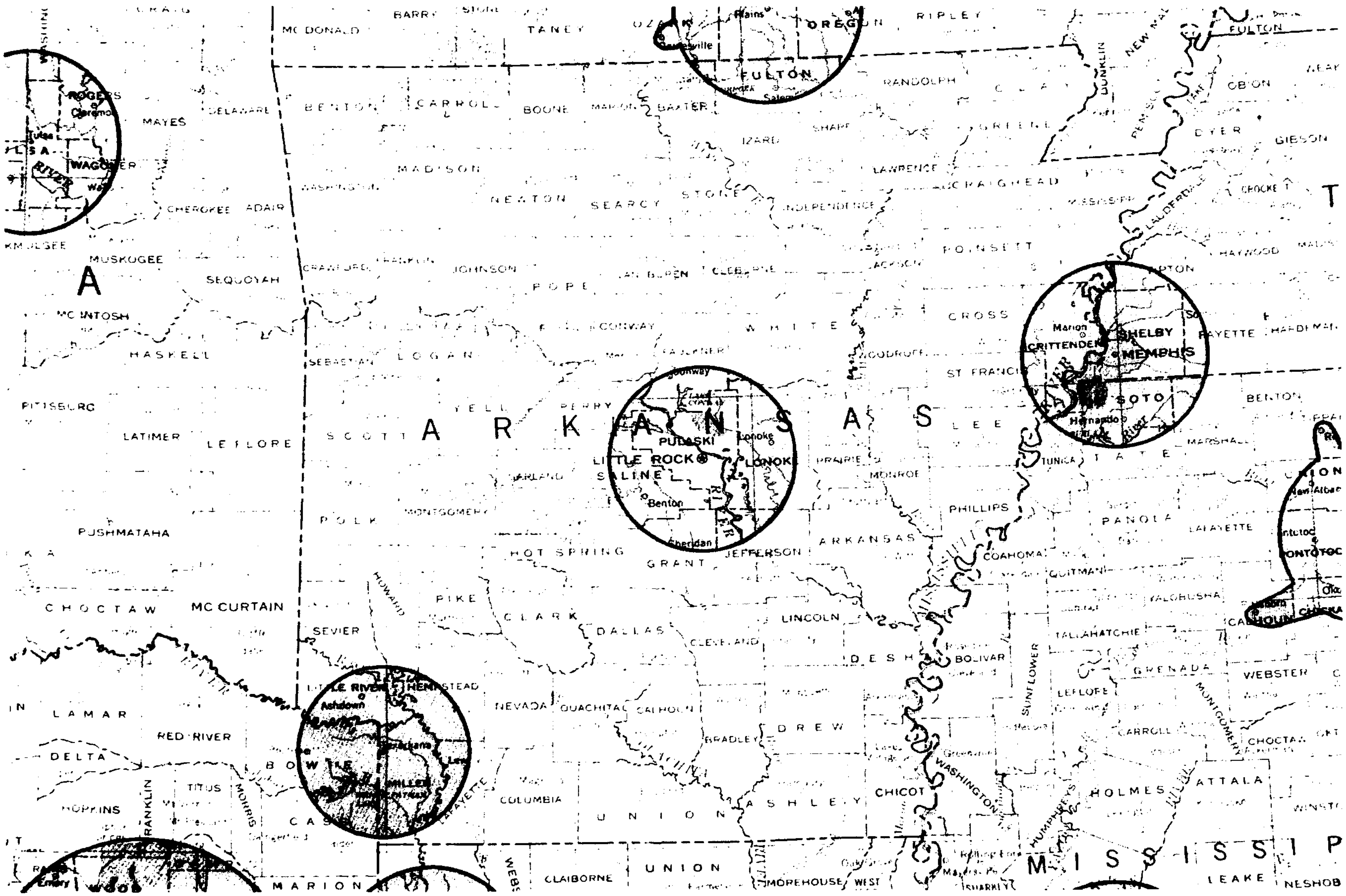


FIGURE A-15 LOCAL OPERATING AREA COVERAGE FOR ARKANSAS

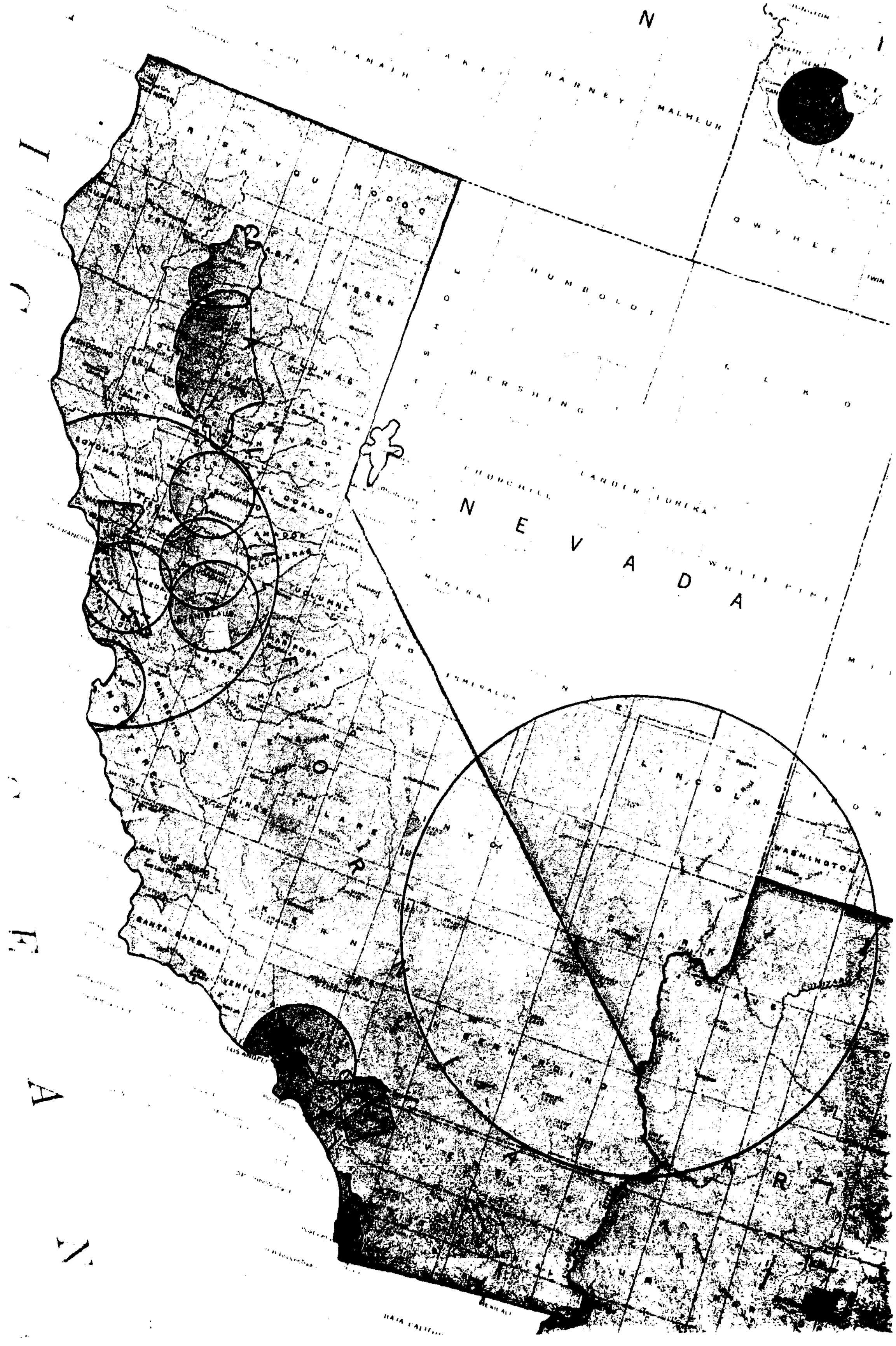


FIGURE A-16 LOCAL OPERATING AREA COVERAGE FOR CALIFORNIA

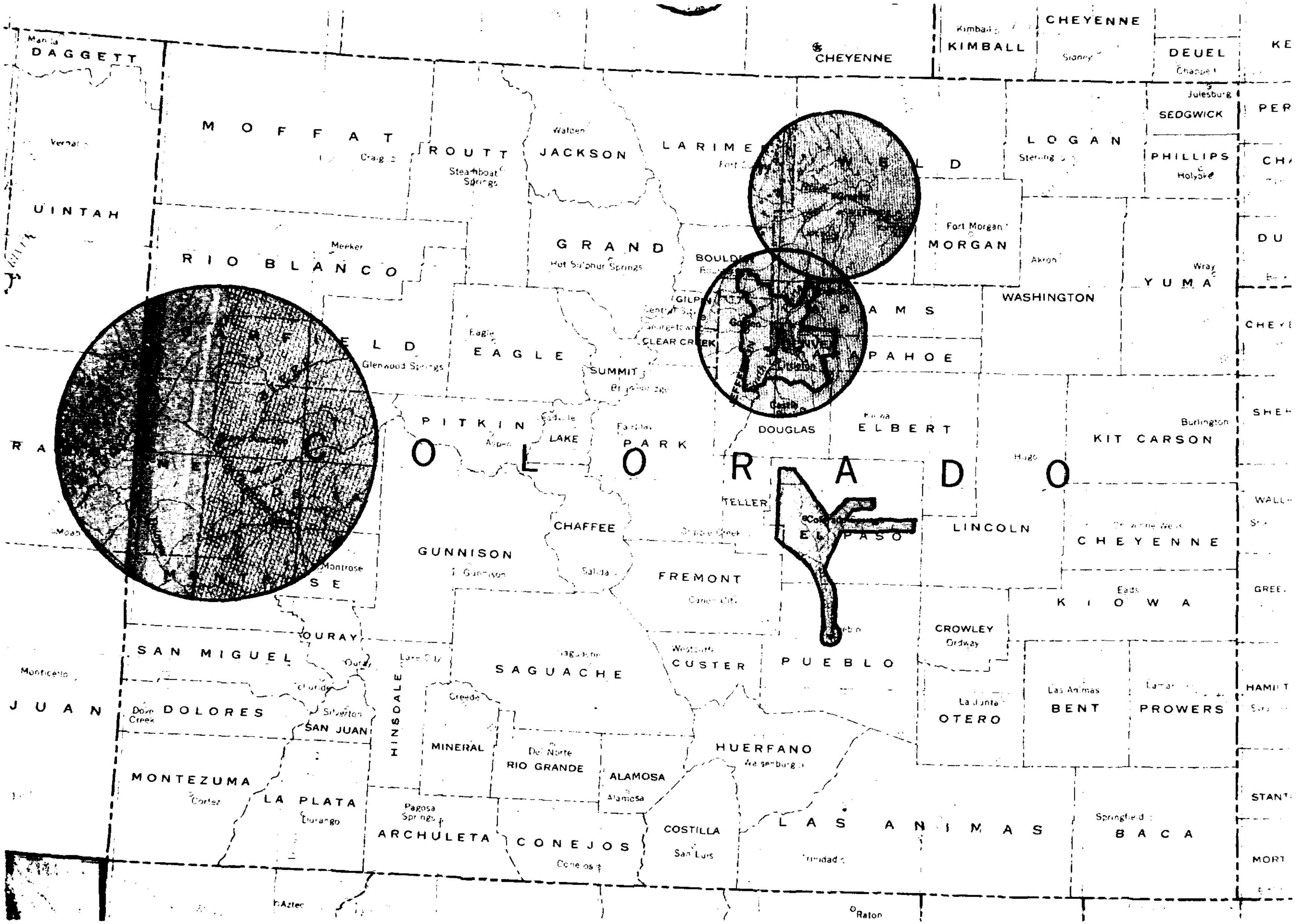


FIGURE A-17 LOCAL OPERATING AREA COVERAGE FOR COLORADO

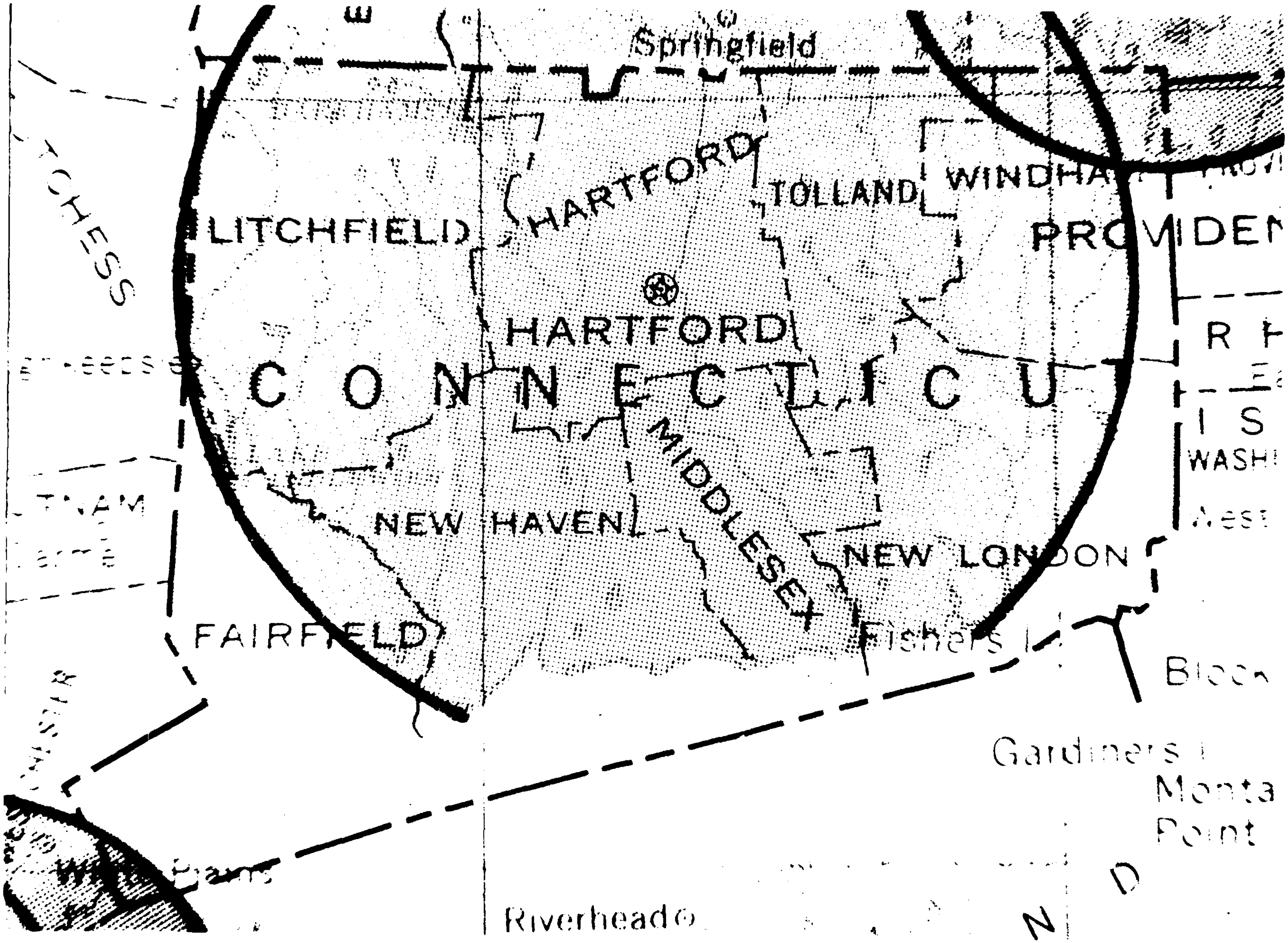


FIGURE A-18 LOCAL OPERATING AREA COVERAGE FOR CONNECTICUT

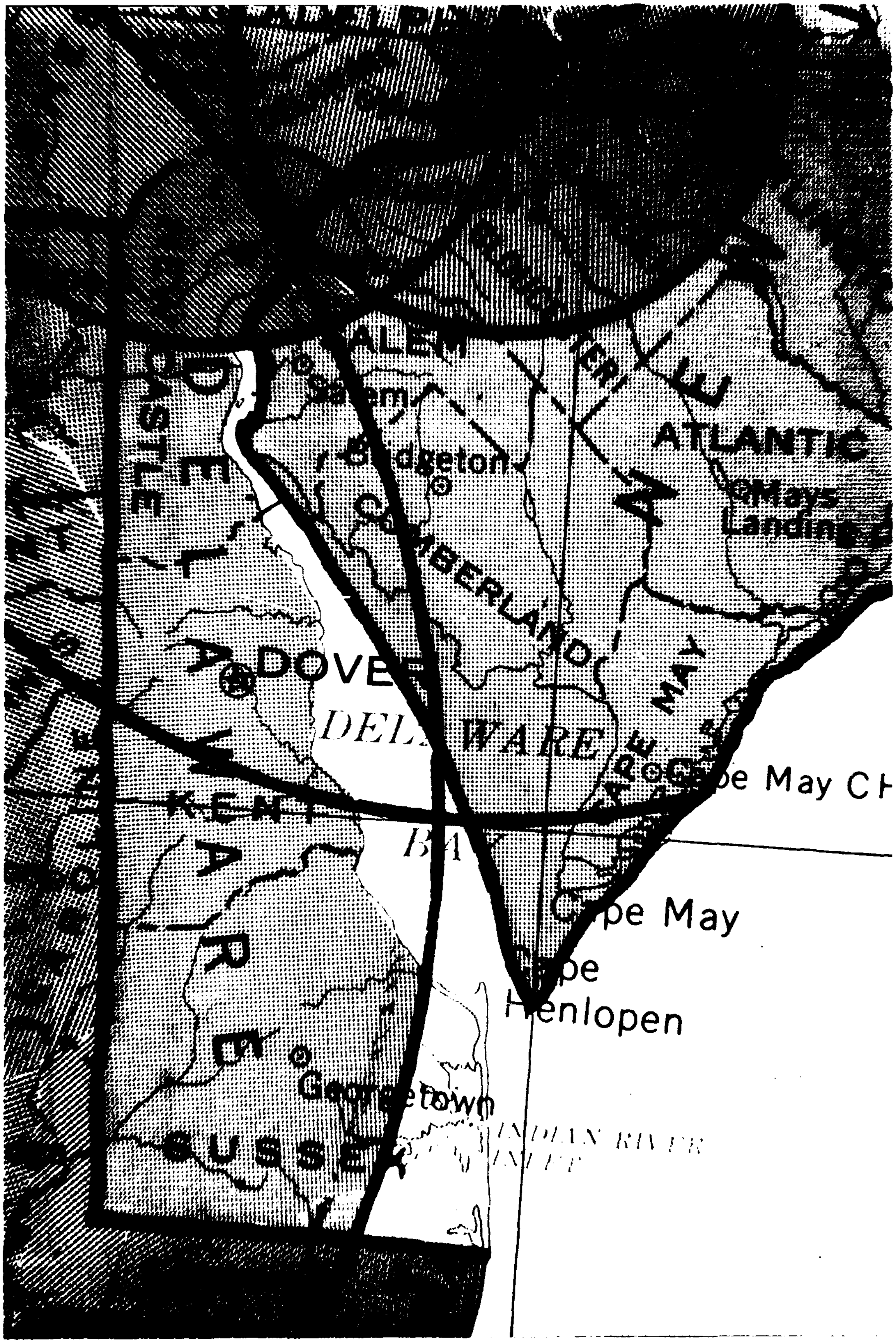


FIGURE A-19 LOCAL OPERATING AREA COVERAGE FOR DELAWARE

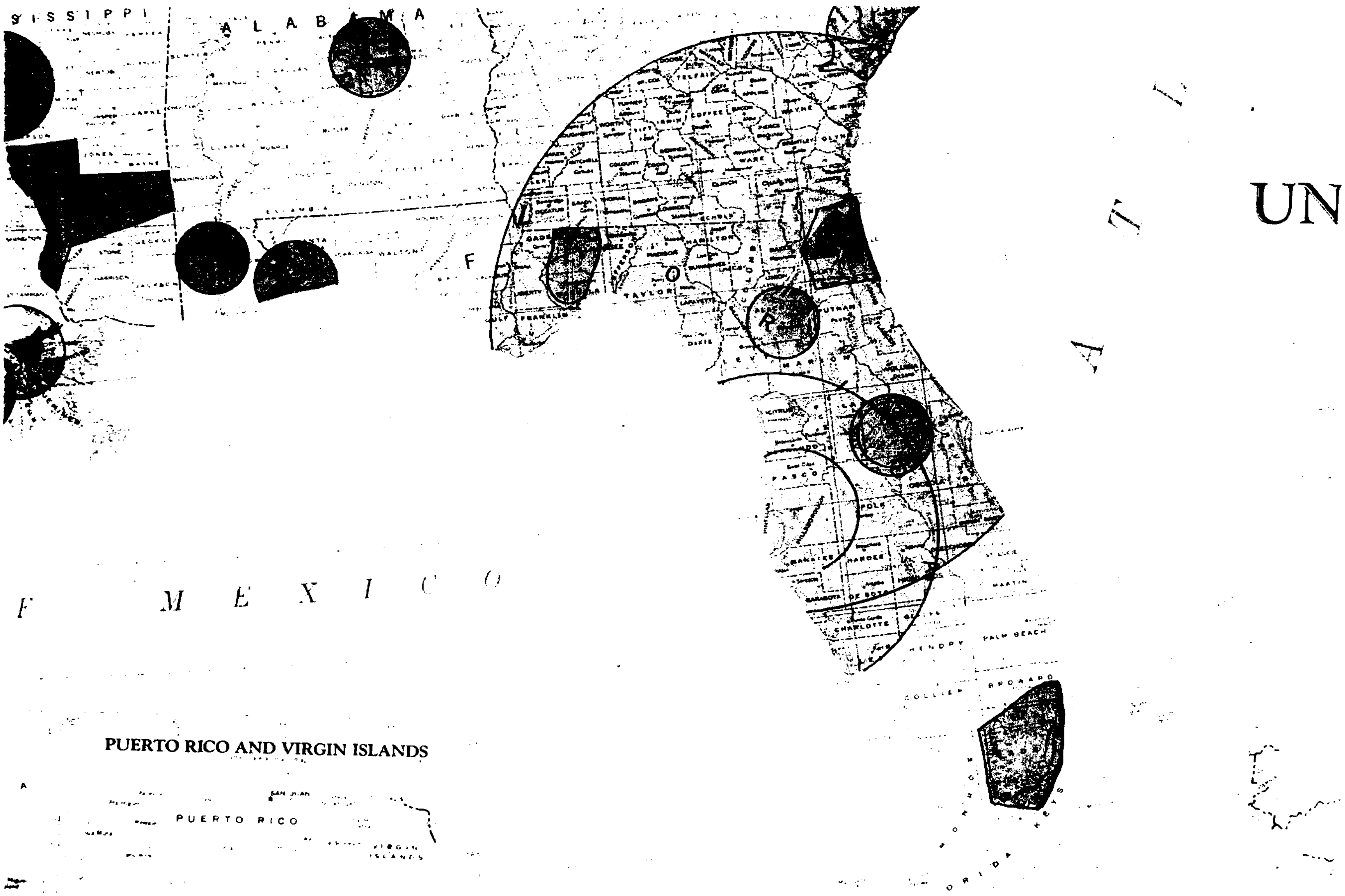


FIGURE A-20 LOCAL OPERATING AREA COVERAGE FOR FLORIDA

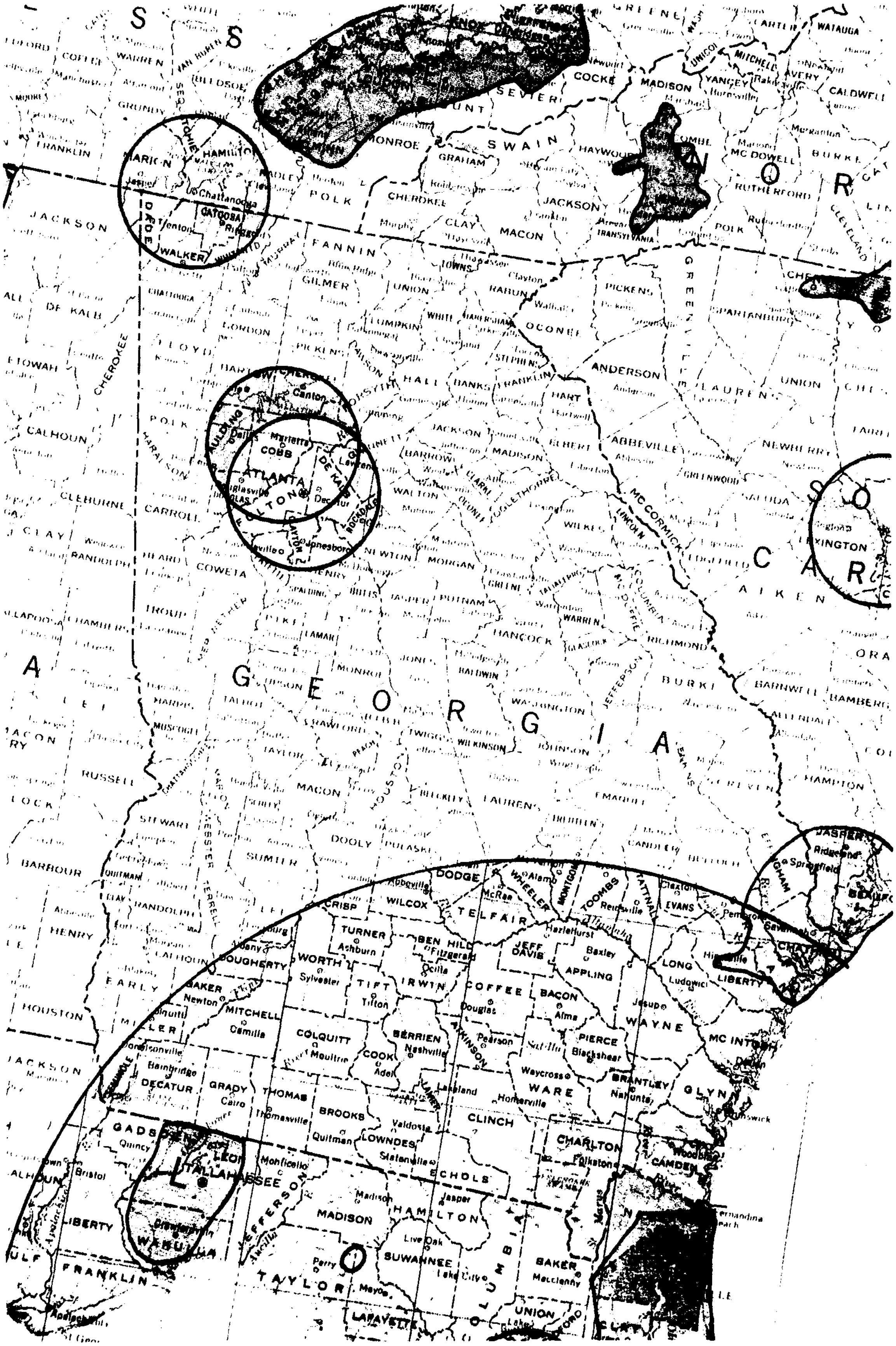


FIGURE A-21 LOCAL OPERATING AREA COVERAGE FOR GEORGIA

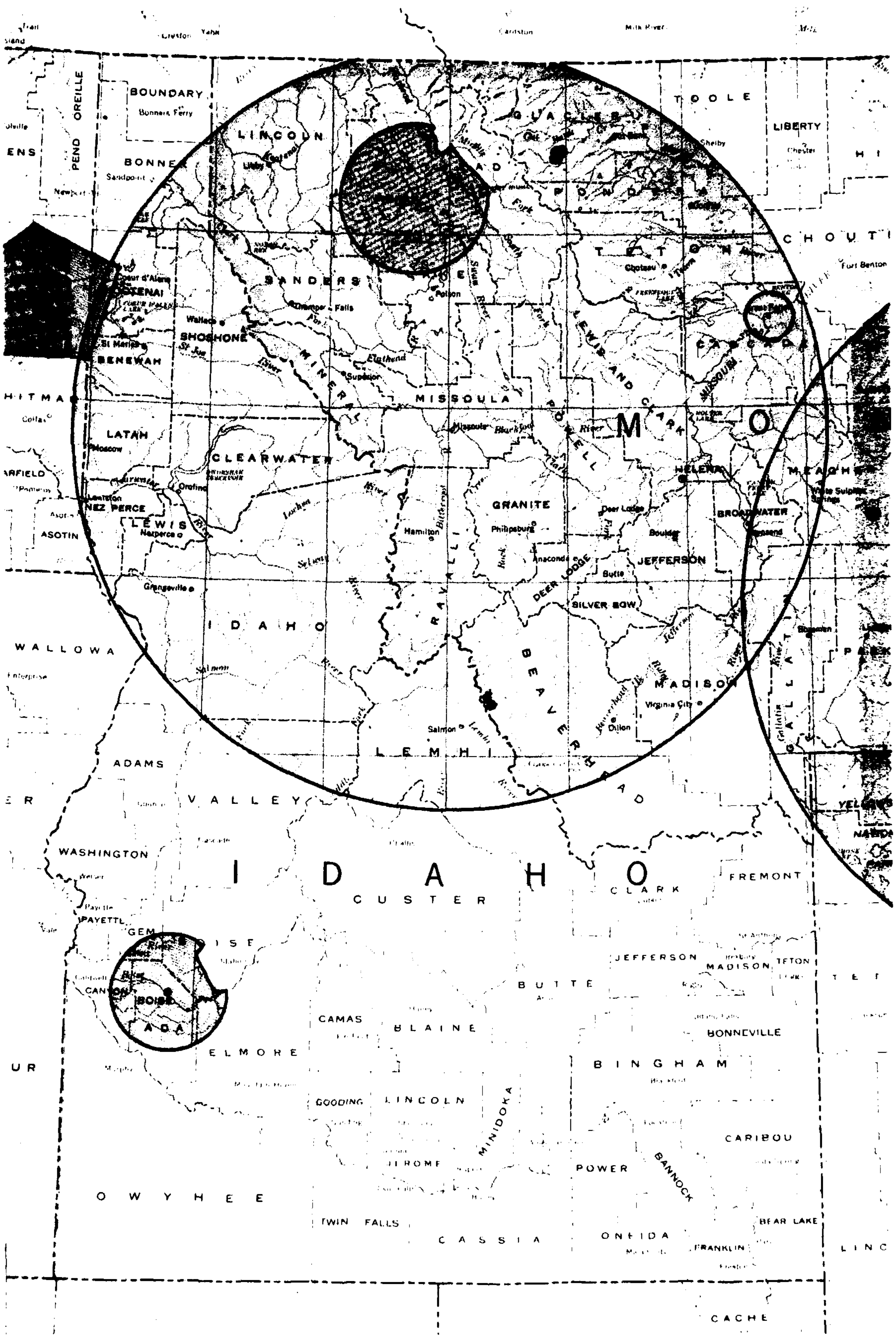


FIGURE A-22 LOCAL OPERATING AREA COVERAGE FOR IDAHO

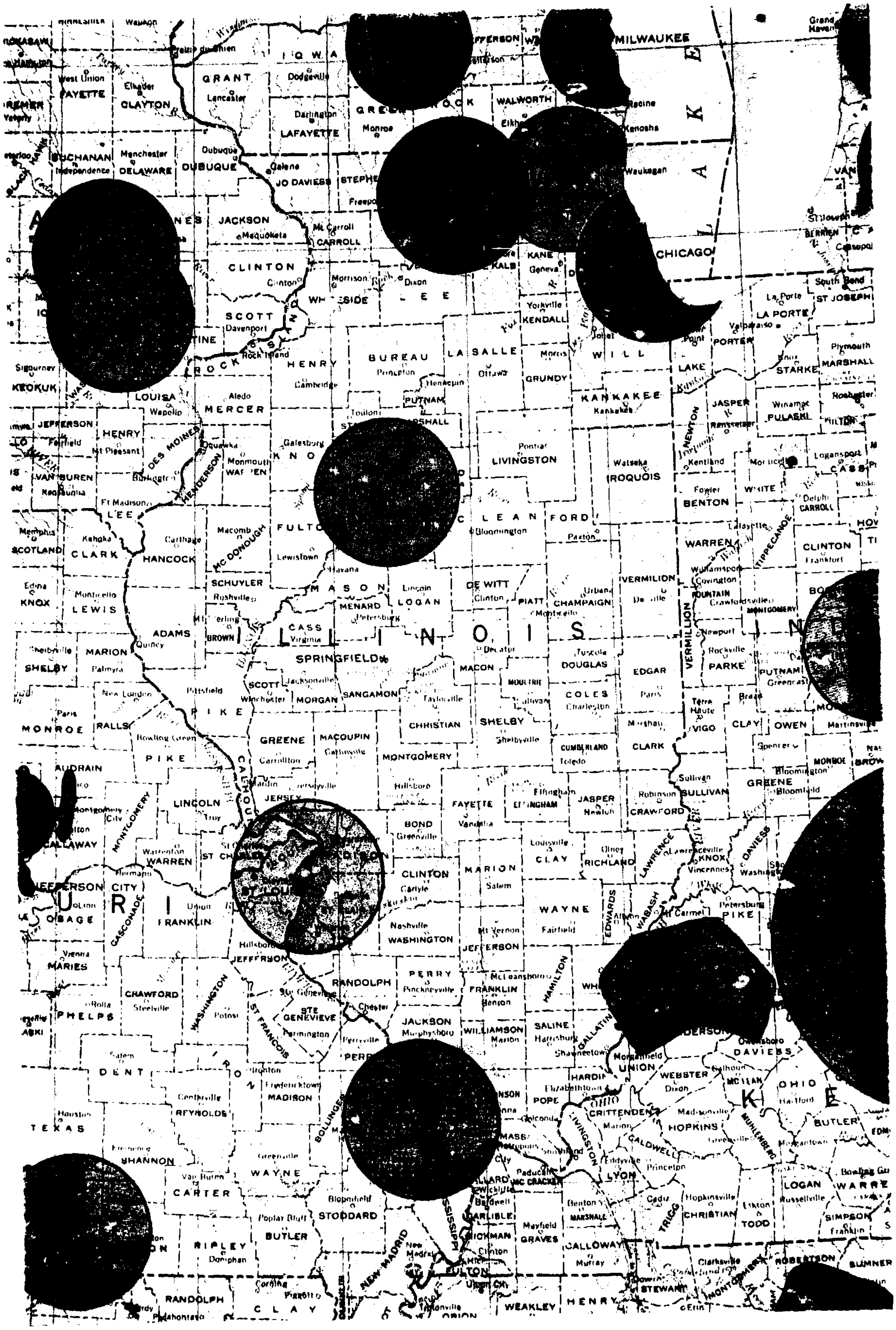


FIGURE A-23 LOCAL OPERATING AREA COVERAGE FOR ILLINOIS

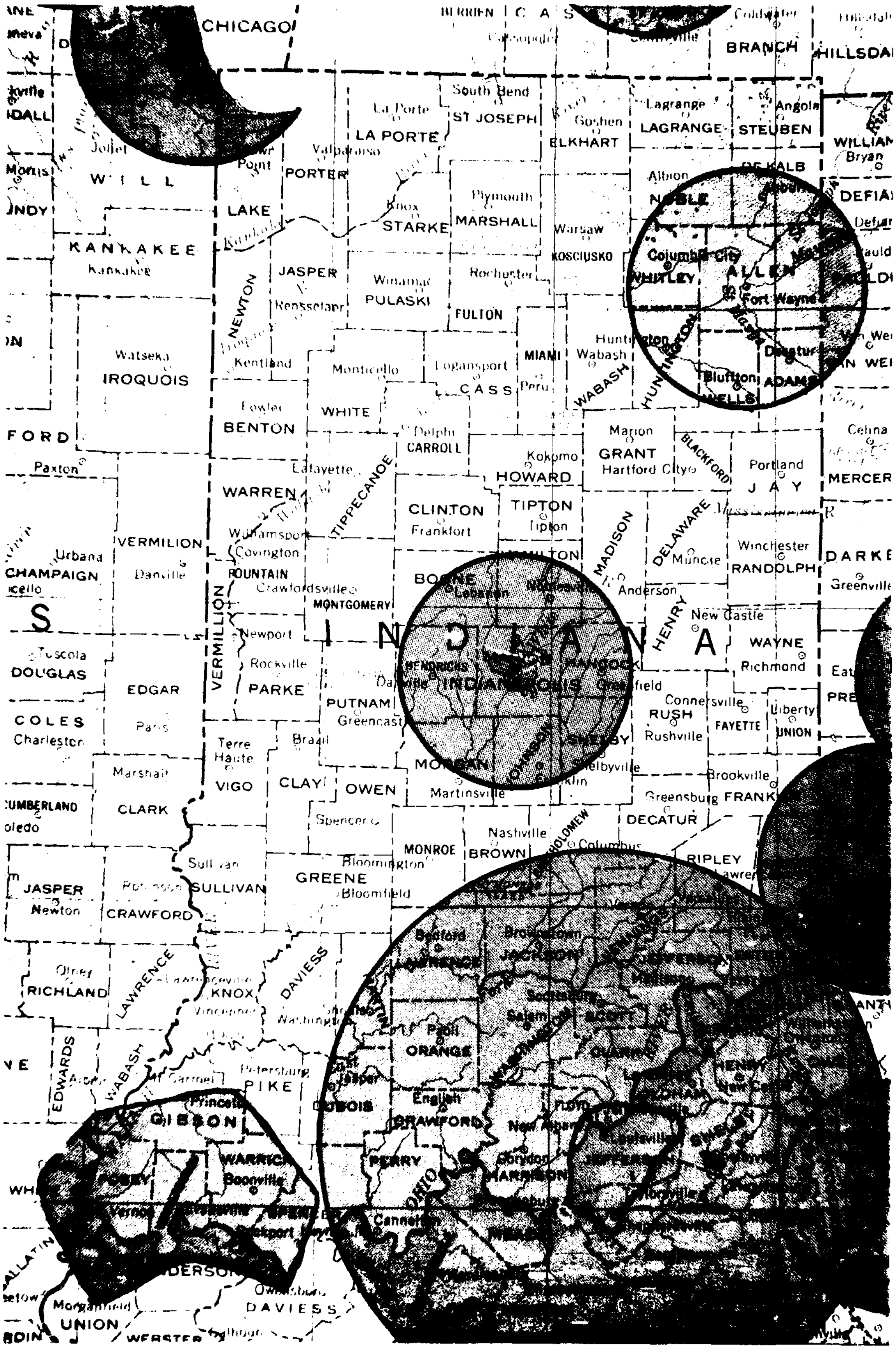


FIGURE A-24 LOCAL OPERATING AREA COVERAGE FOR INDIANA

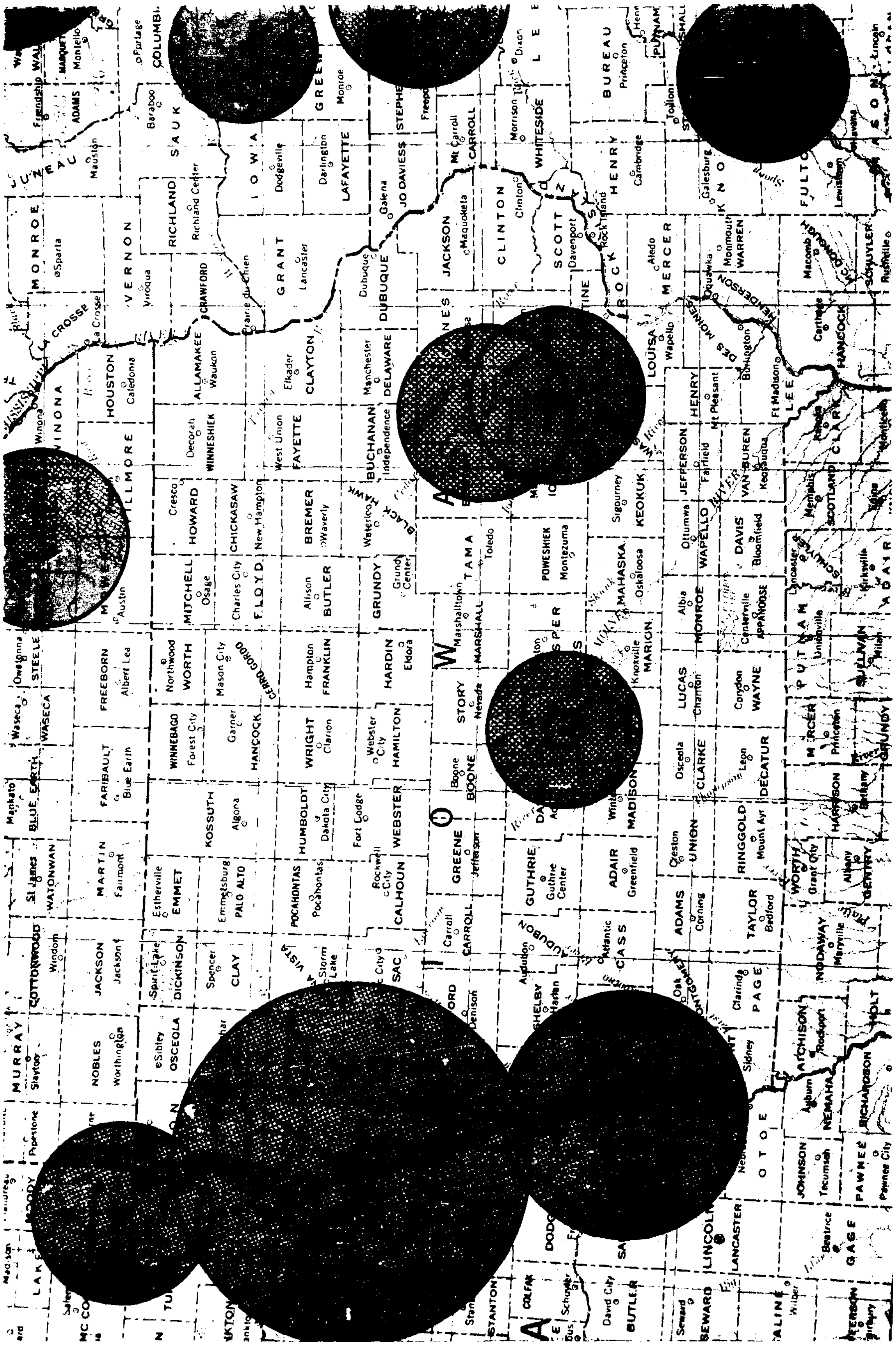


FIGURE A-25 LOCAL OPERATING AREA COVERAGE FOR IOWA

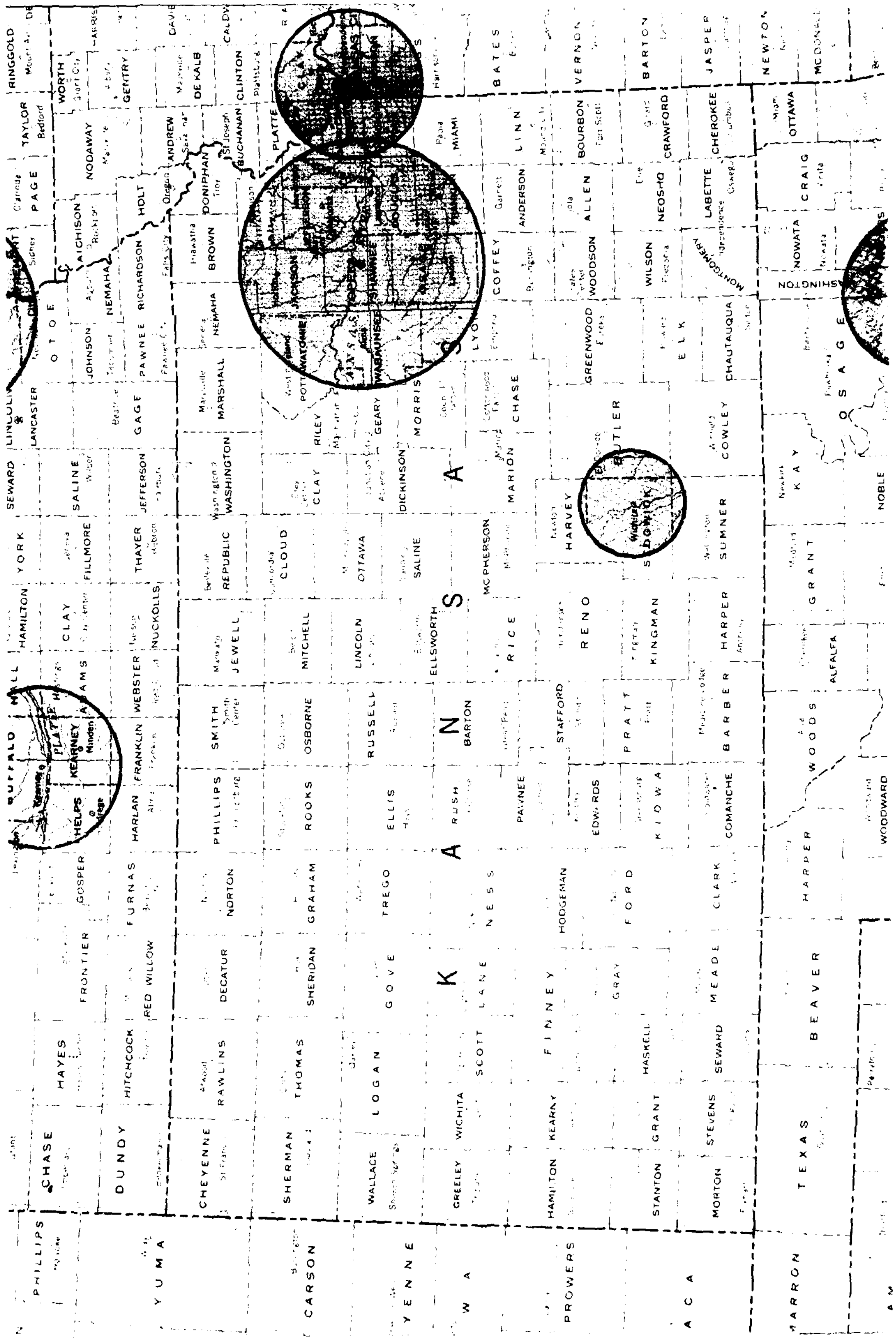


FIGURE A-26 LOCAL OPERATING AREA COVERAGE FOR KANSAS

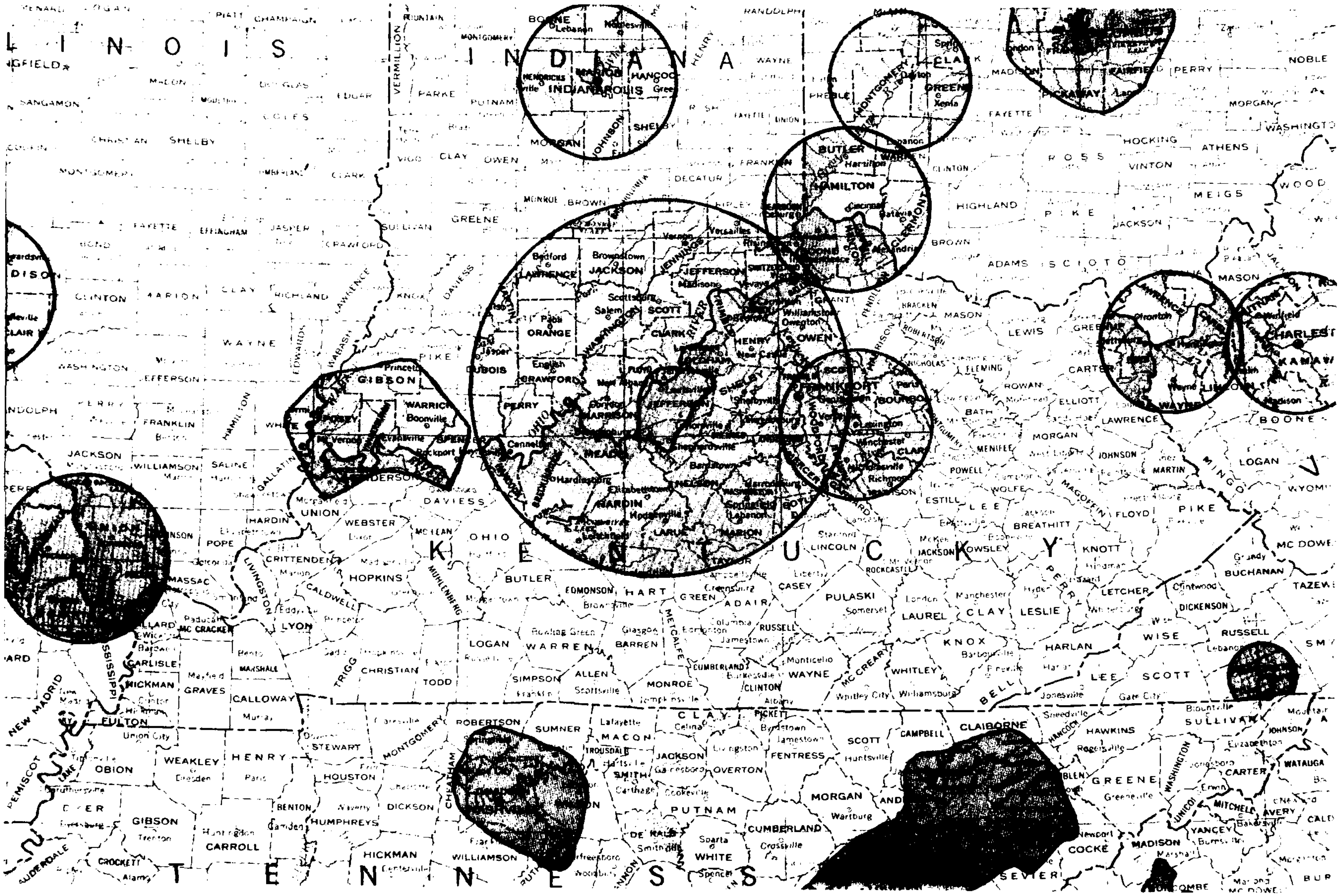


FIGURE A-27 LOCAL OPERATING AREA COVERAGE FOR KENTUCKY

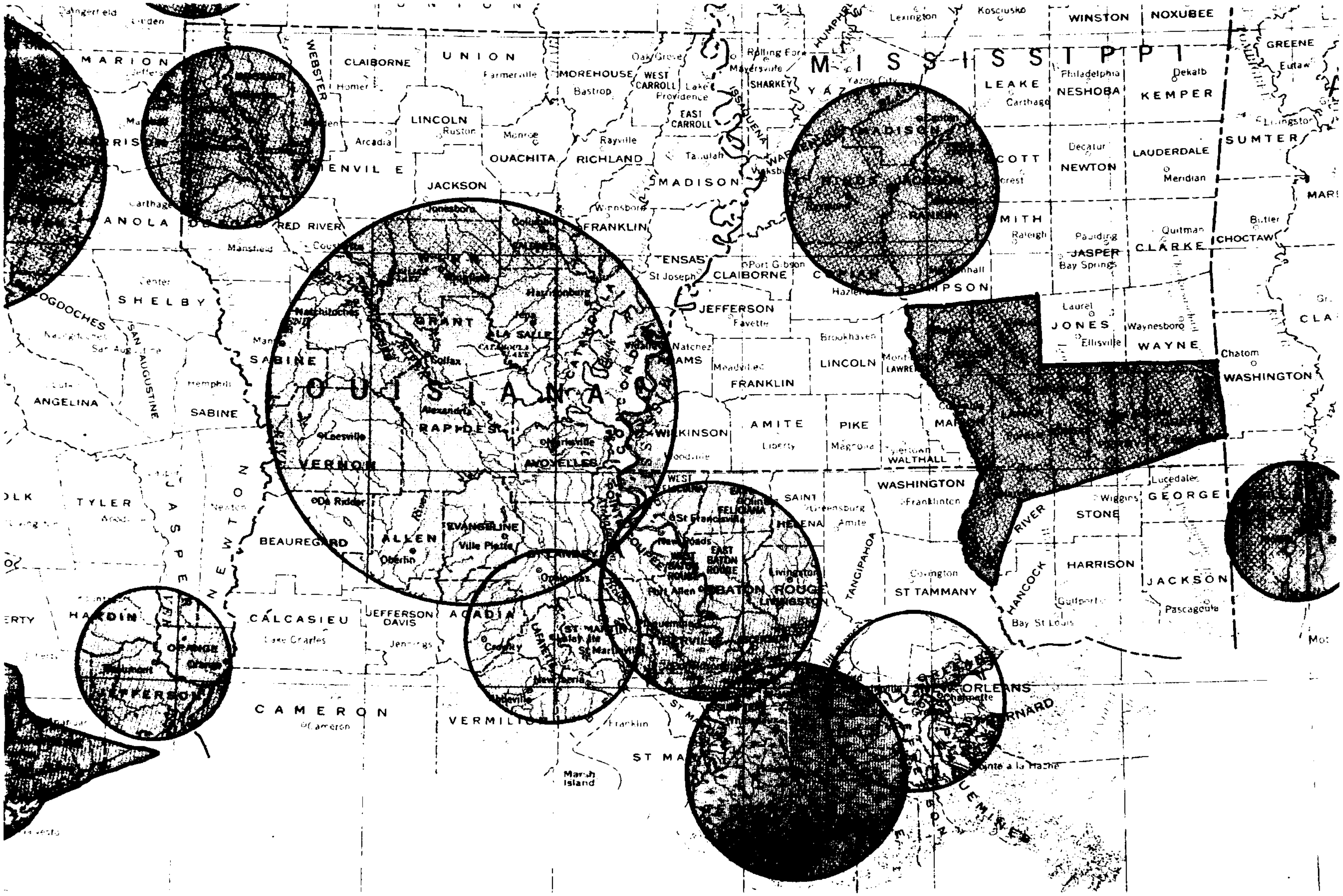


FIGURE A-28 LOCAL OPERATING AREA COVERAGE FOR LOUISIANA

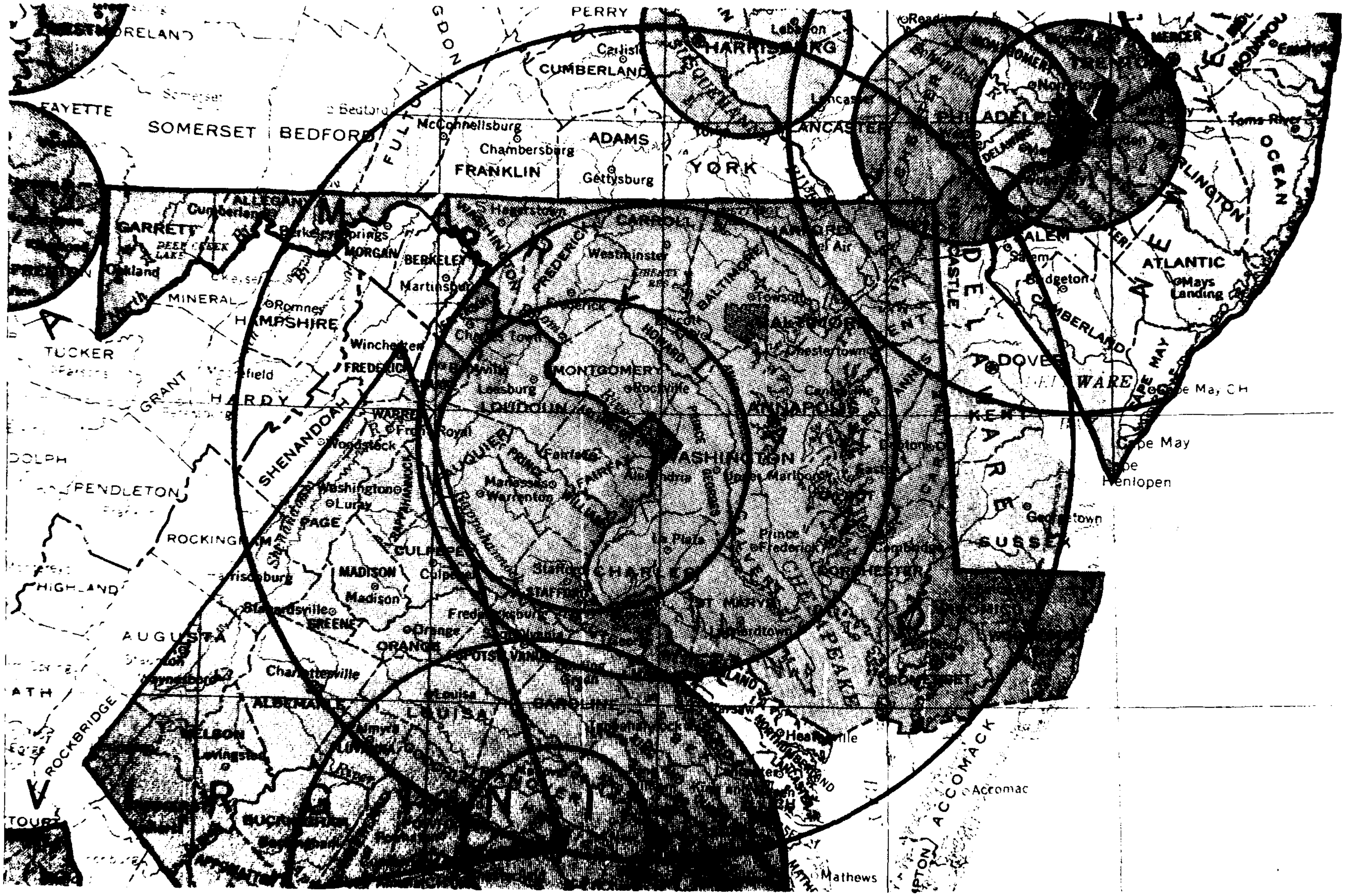


FIGURE A-29 LOCAL OPERATING AREA COVERAGE FOR MARYLAND

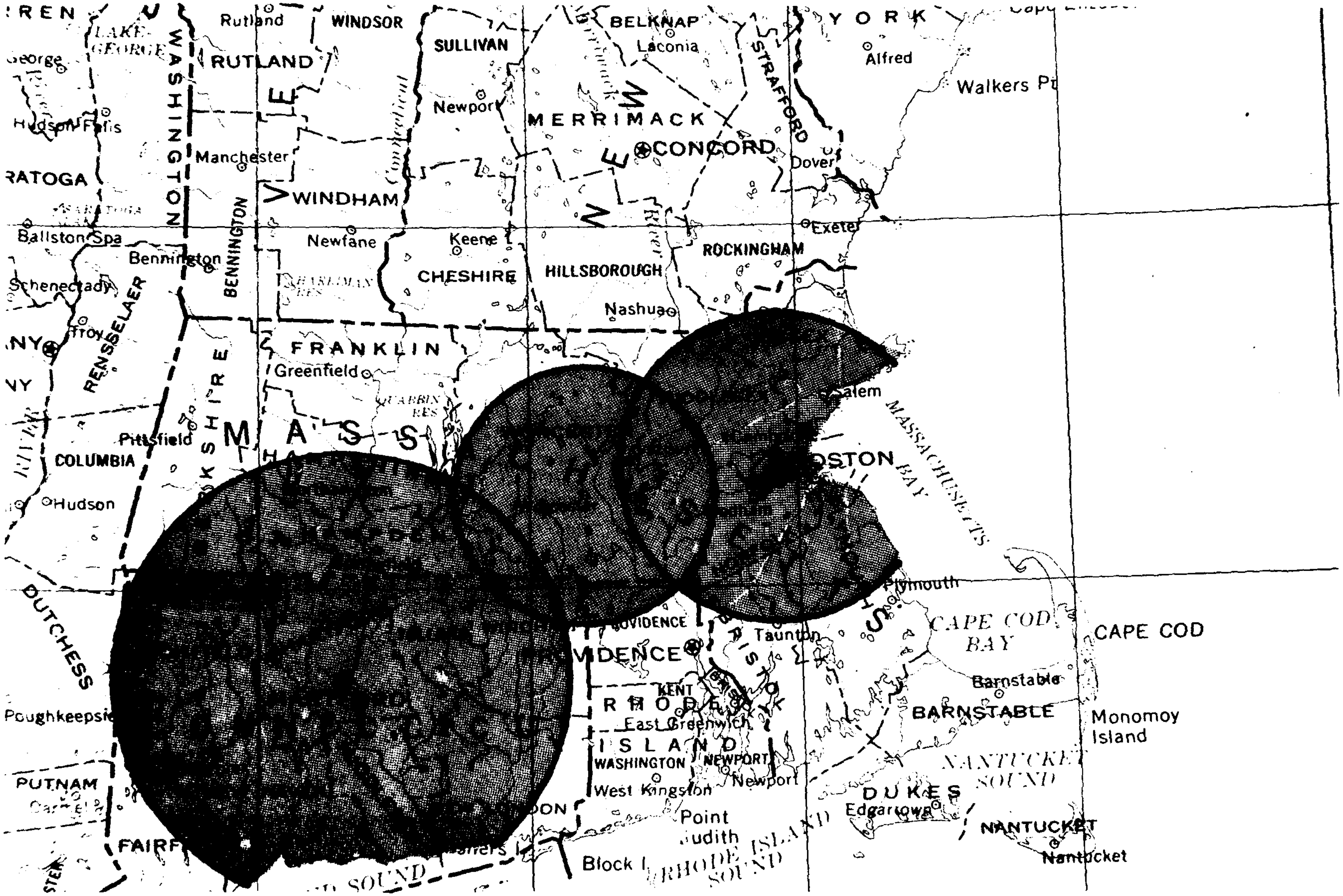


FIGURE A-30 LOCAL OPERATING AREA COVERAGE FOR MASSACHUSETTS

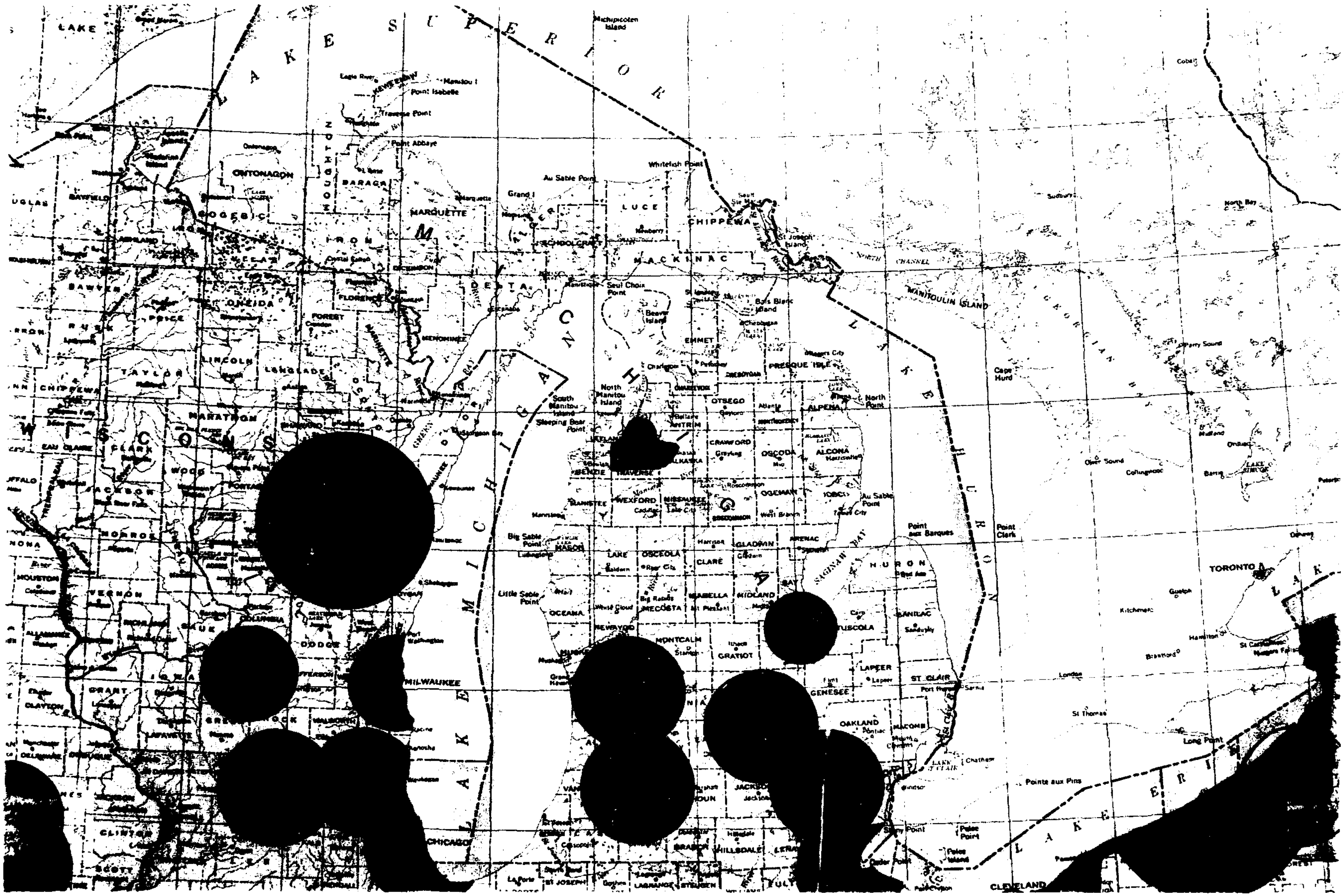


FIGURE A-31 LOCAL OPERATING AREA COVERAGE FOR MICHIGAN

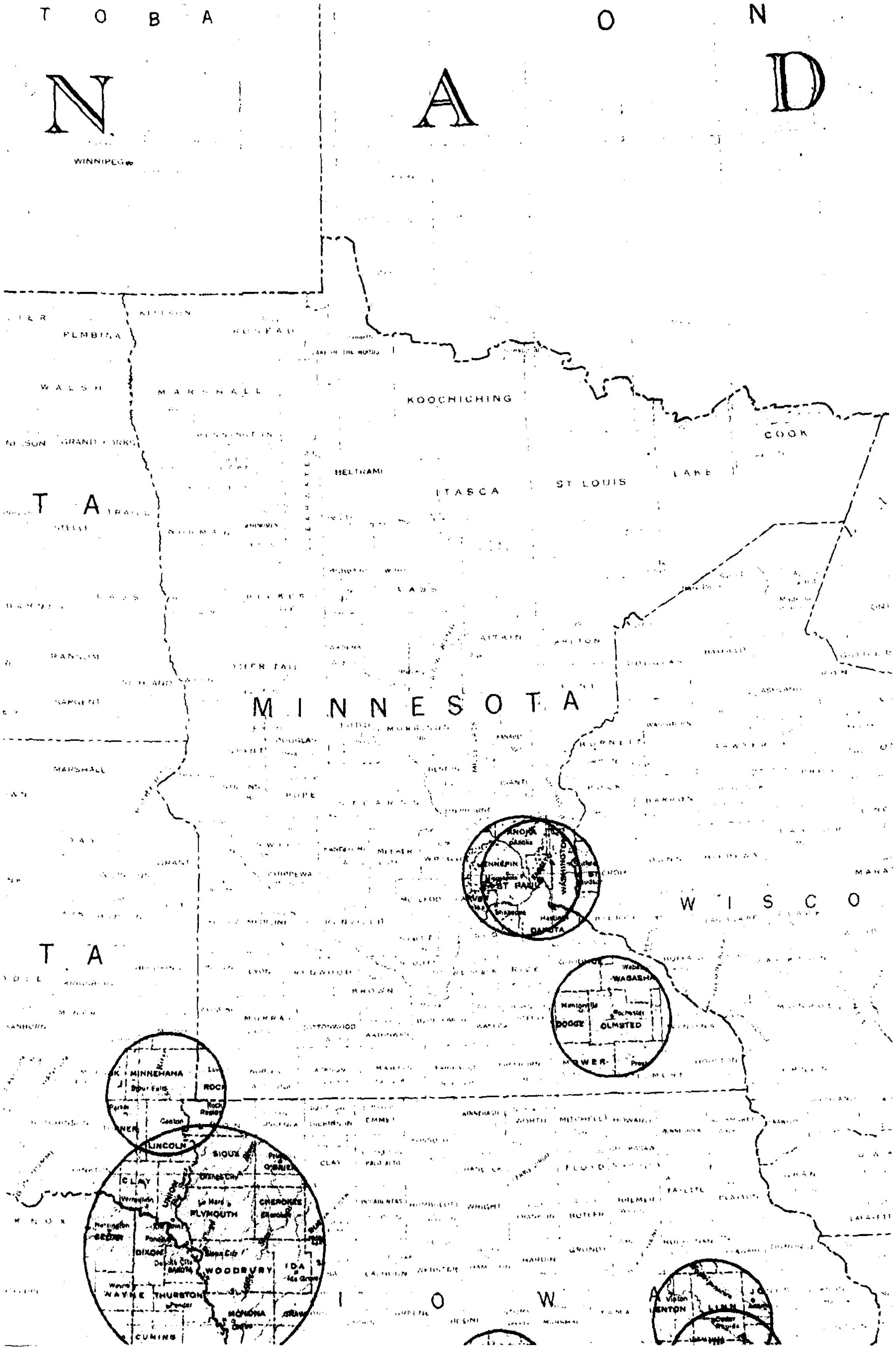


FIGURE A-32 LOCAL OPERATING AREA COVERAGE FOR MINNESOTA

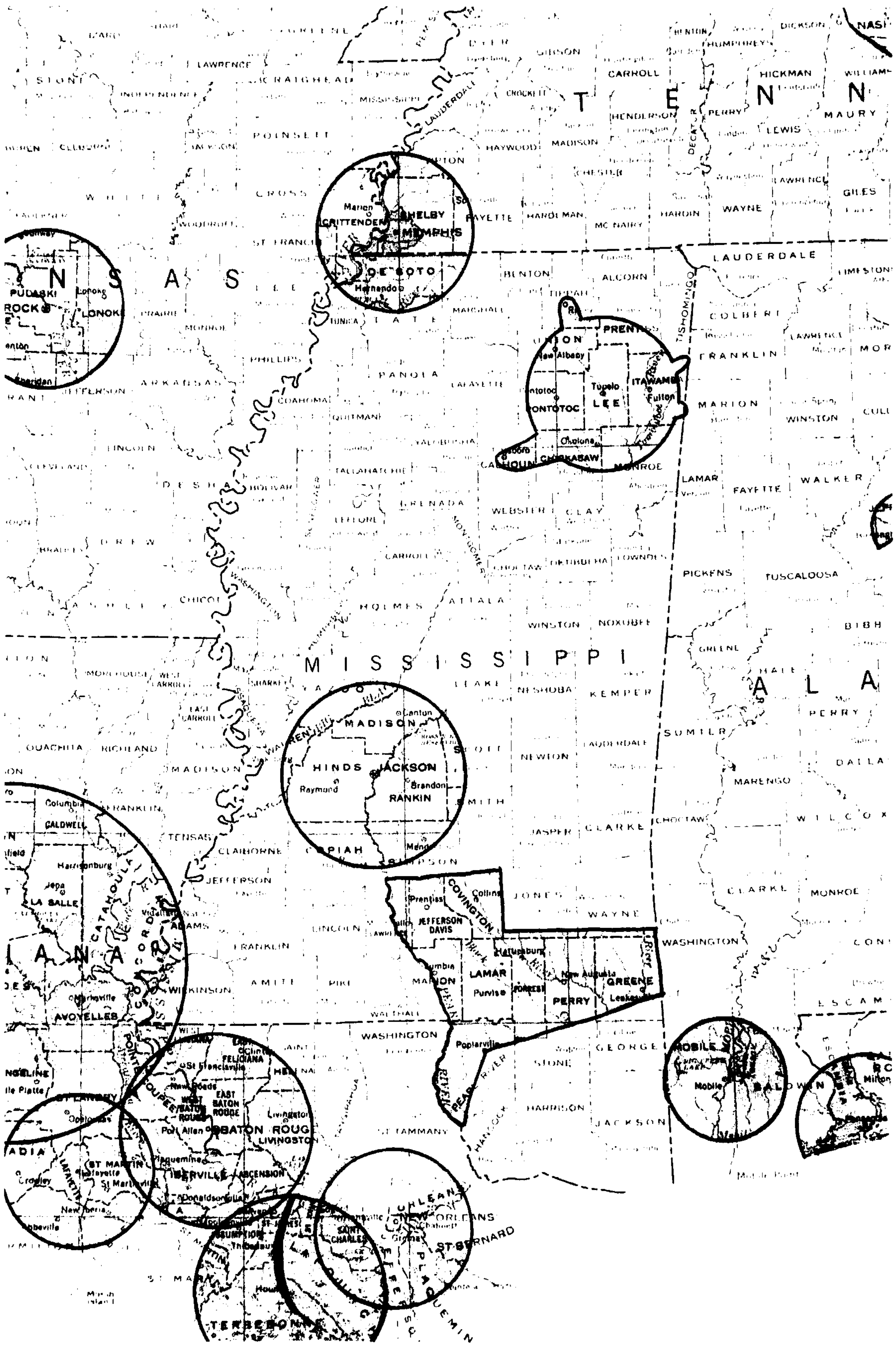


FIGURE A-33 LOCAL OPERATING AREA COVERAGE FOR MISSISSIPPI

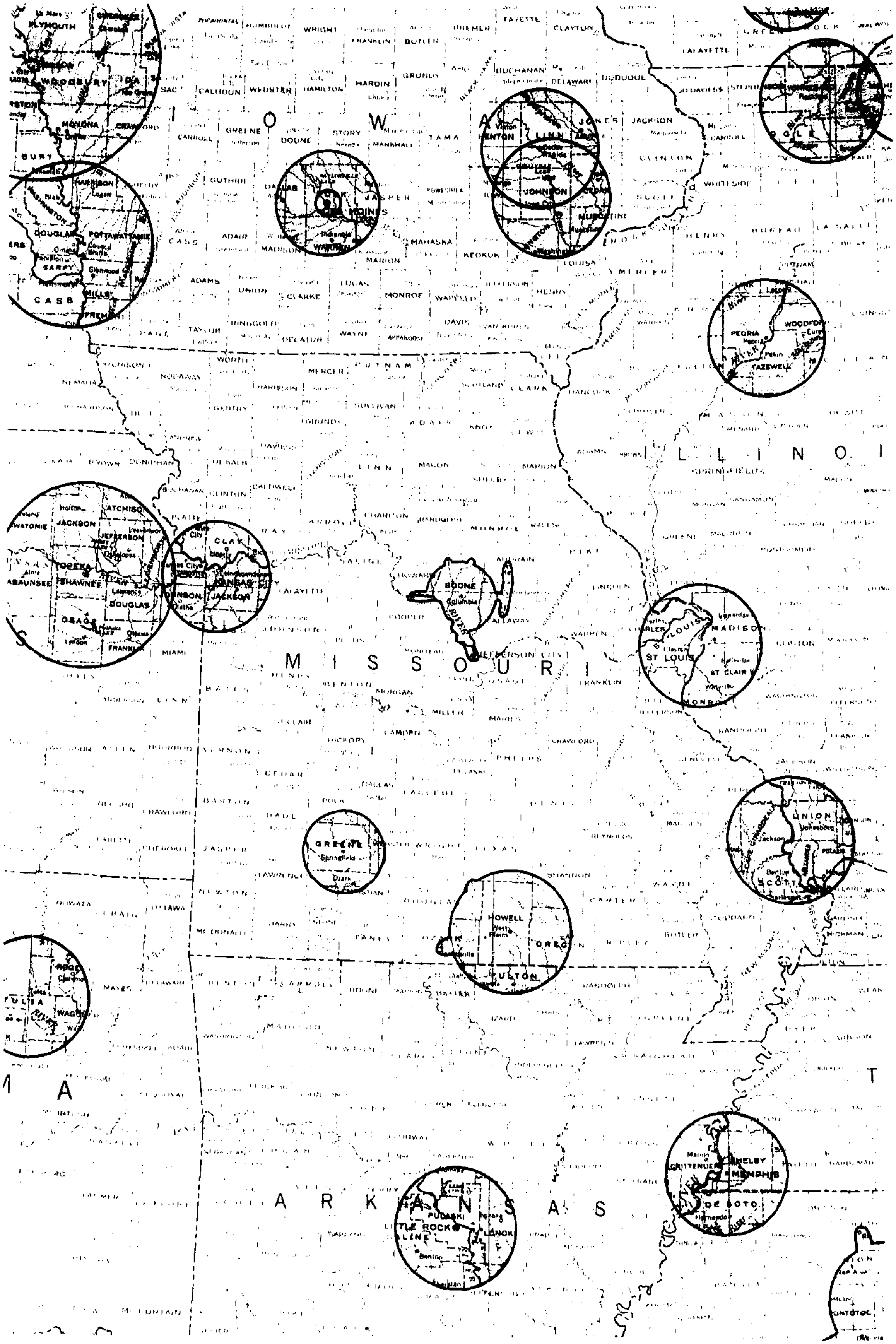


FIGURE A-34 LOCAL OPERATING AREA COVERAGE FOR MISSOURI

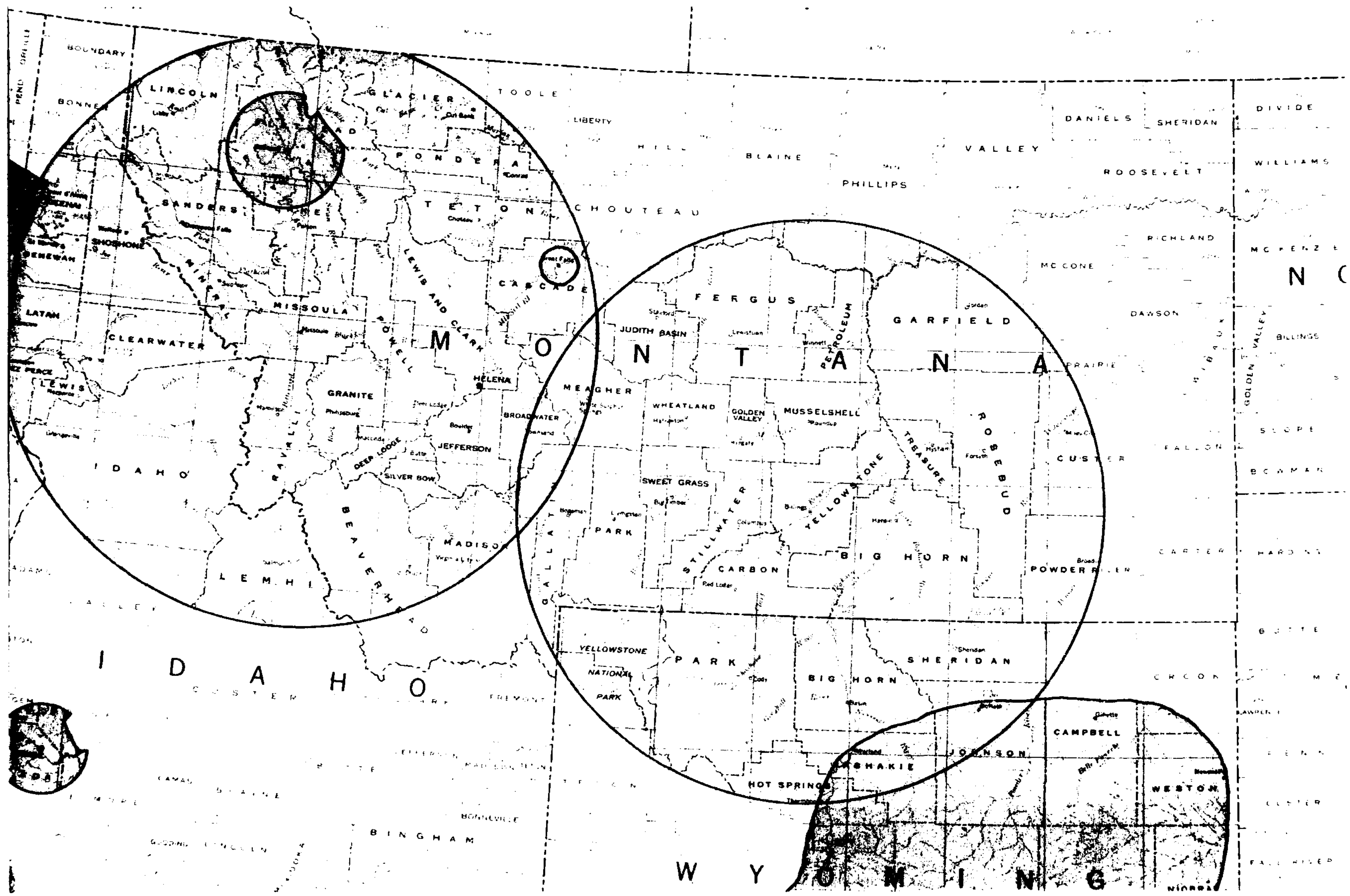


FIGURE A-35 LOCAL OPERATING AREA COVERAGE FOR MONTANA

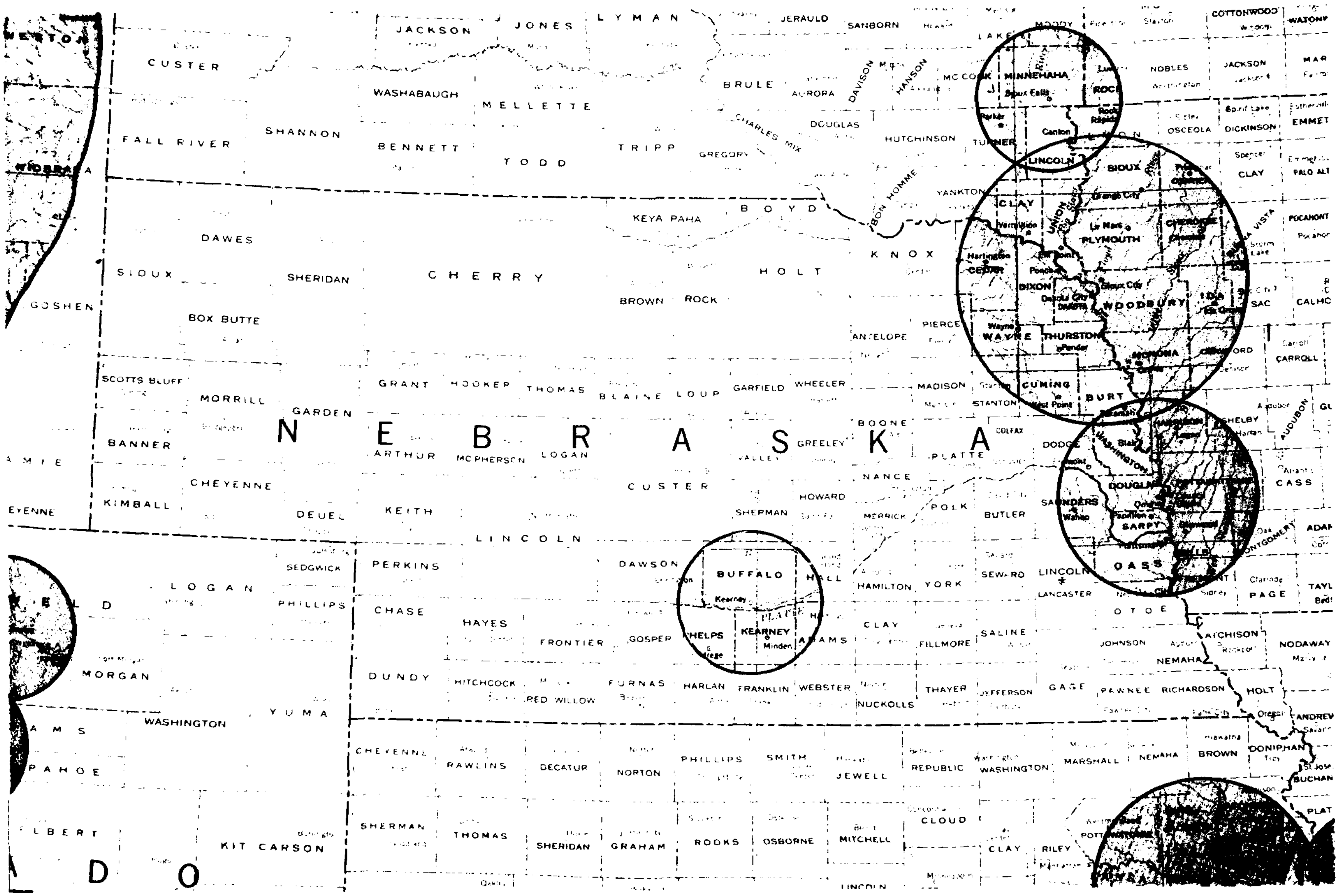


FIGURE A-36 LOCAL OPERATING AREA COVERAGE FOR NEBRASKA

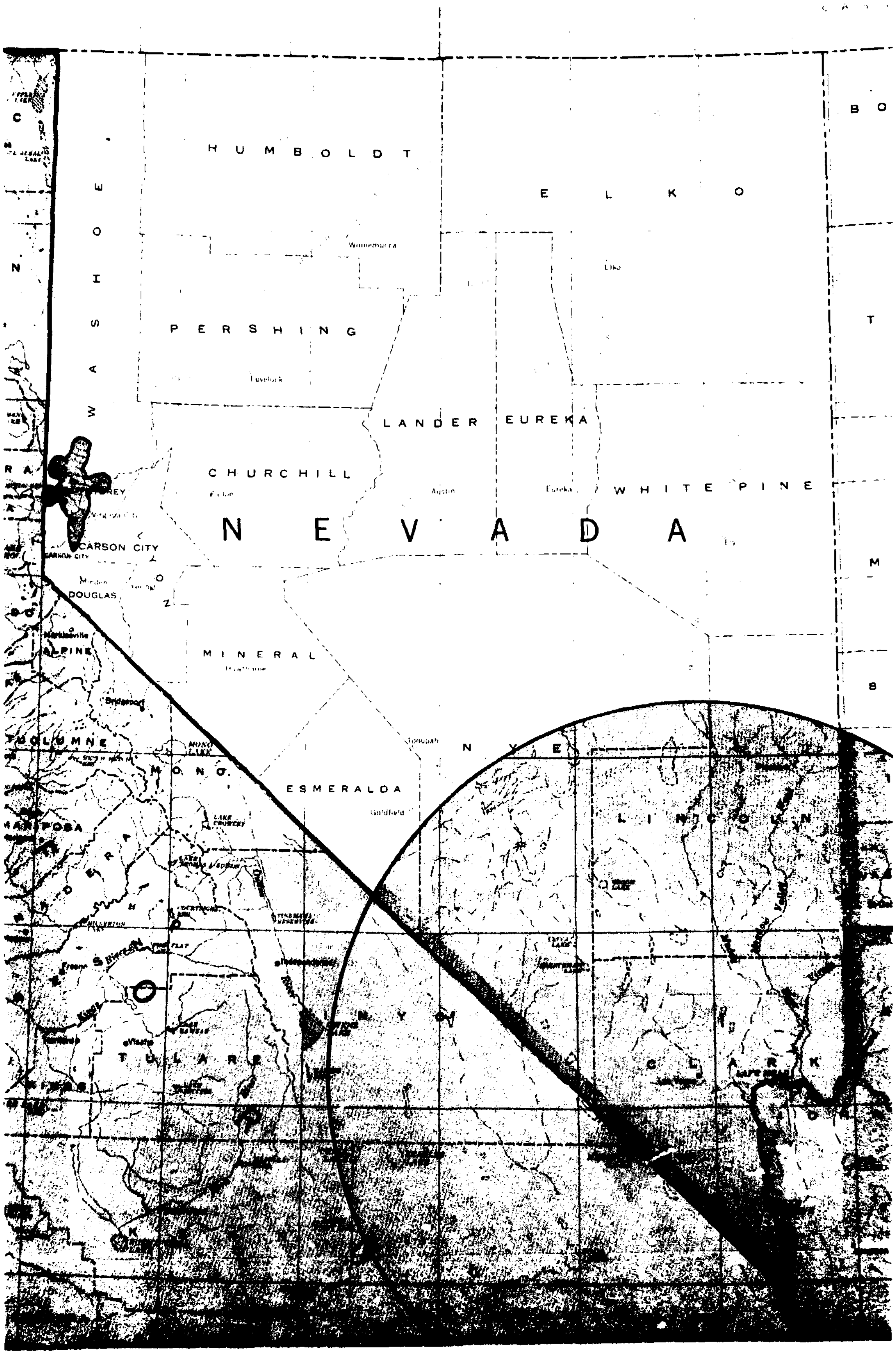


FIGURE A-37 LOCAL OPERATING AREA COVERAGE FOR NEVADA

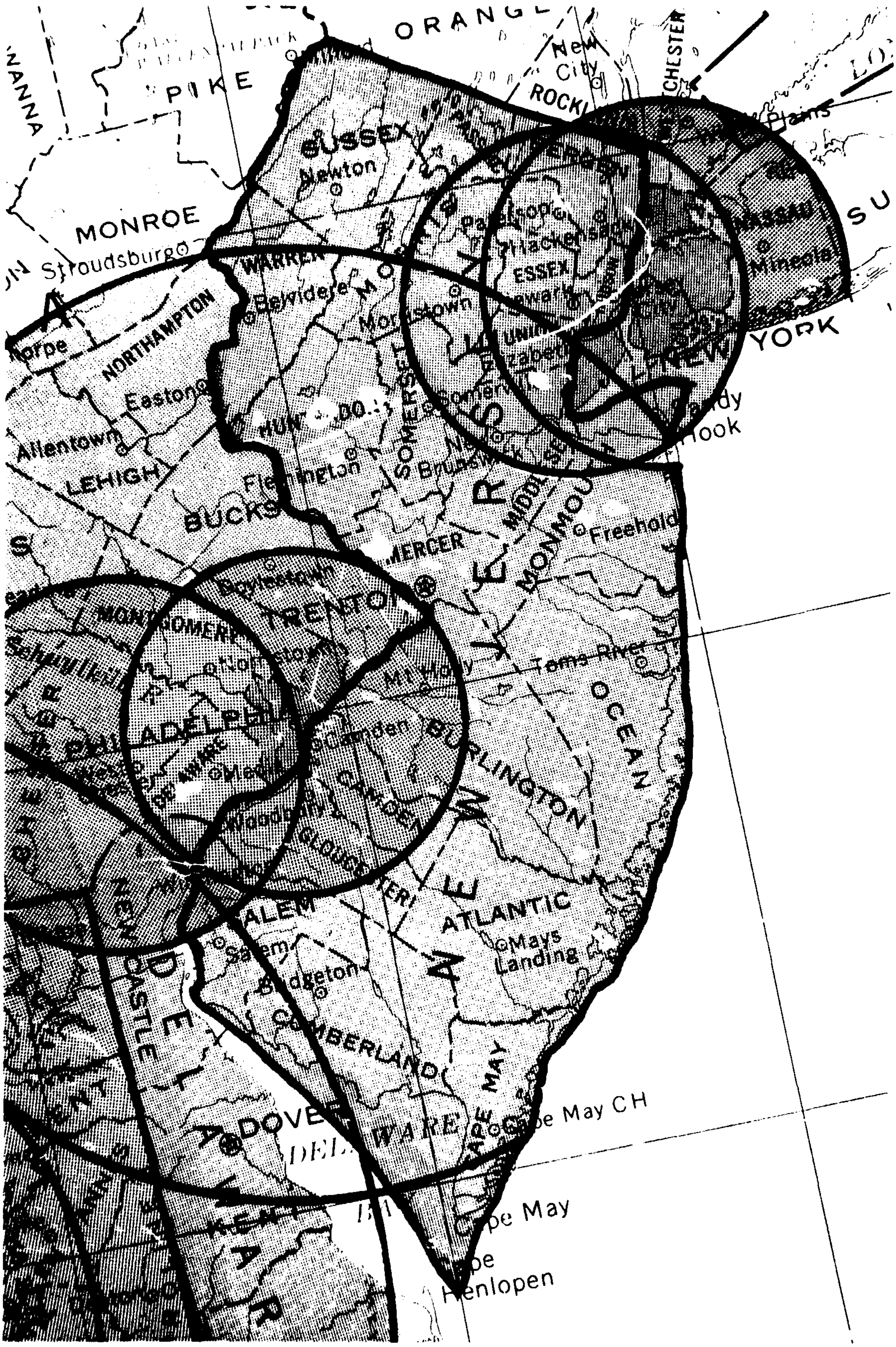


FIGURE A-38 LOCAL OPERATING AREA COVERAGE FOR NEW JERSEY

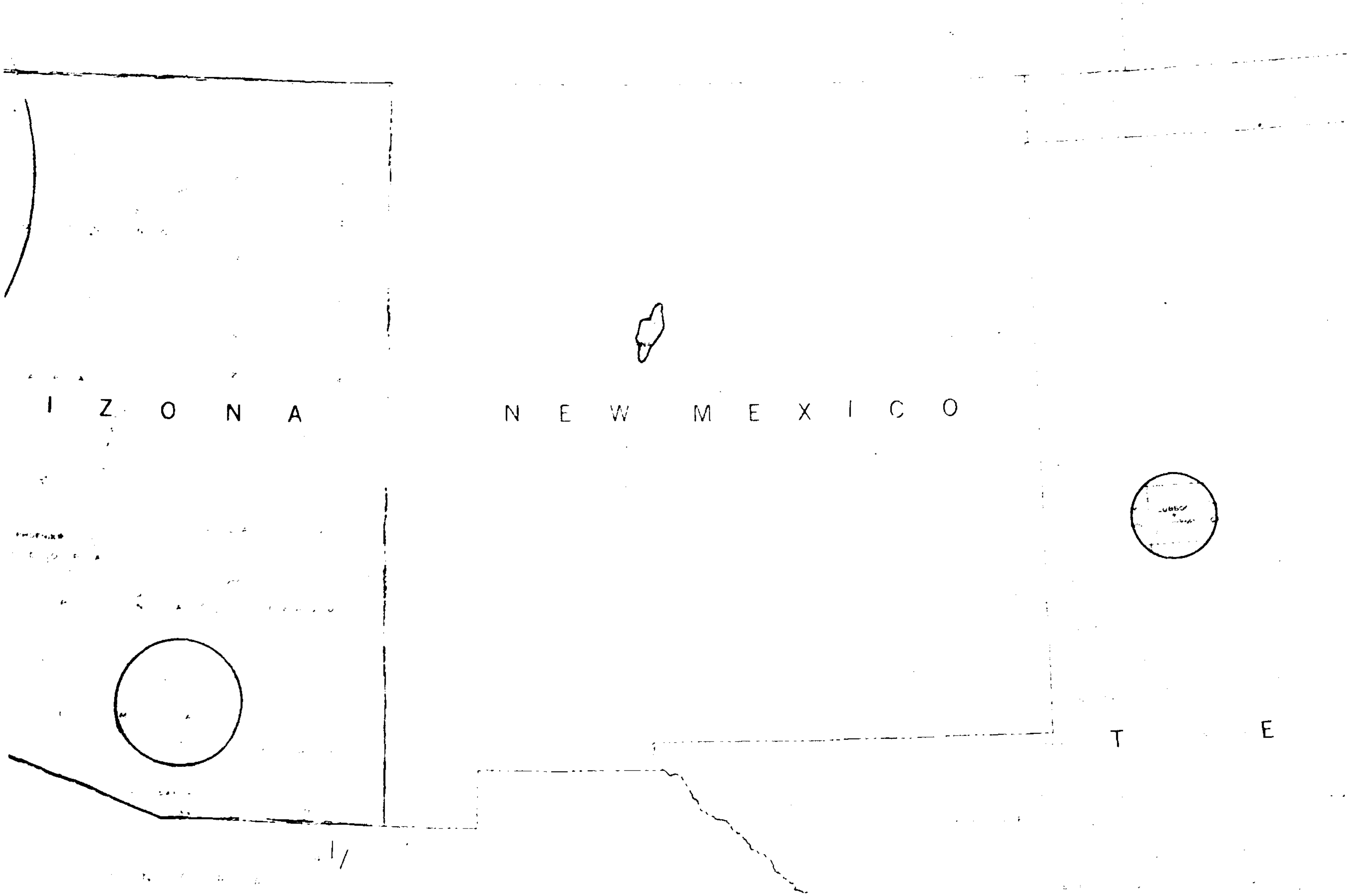


FIGURE A-39 LOCAL OPERATING AREA COVERAGE FOR NEW MEXICO

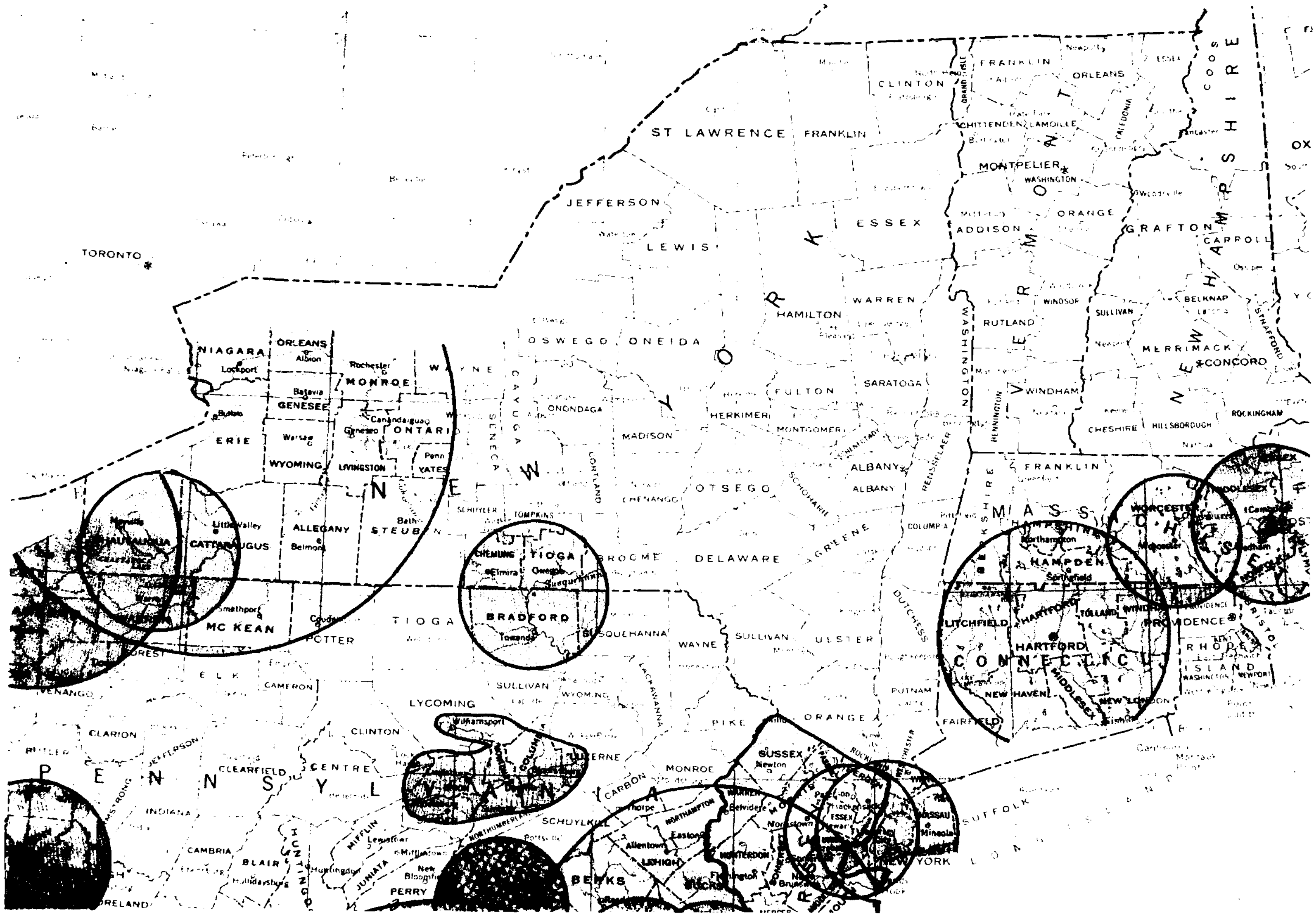


FIGURE A-40 LOCAL OPERATING AREA COVERAGE FOR NEW YORK

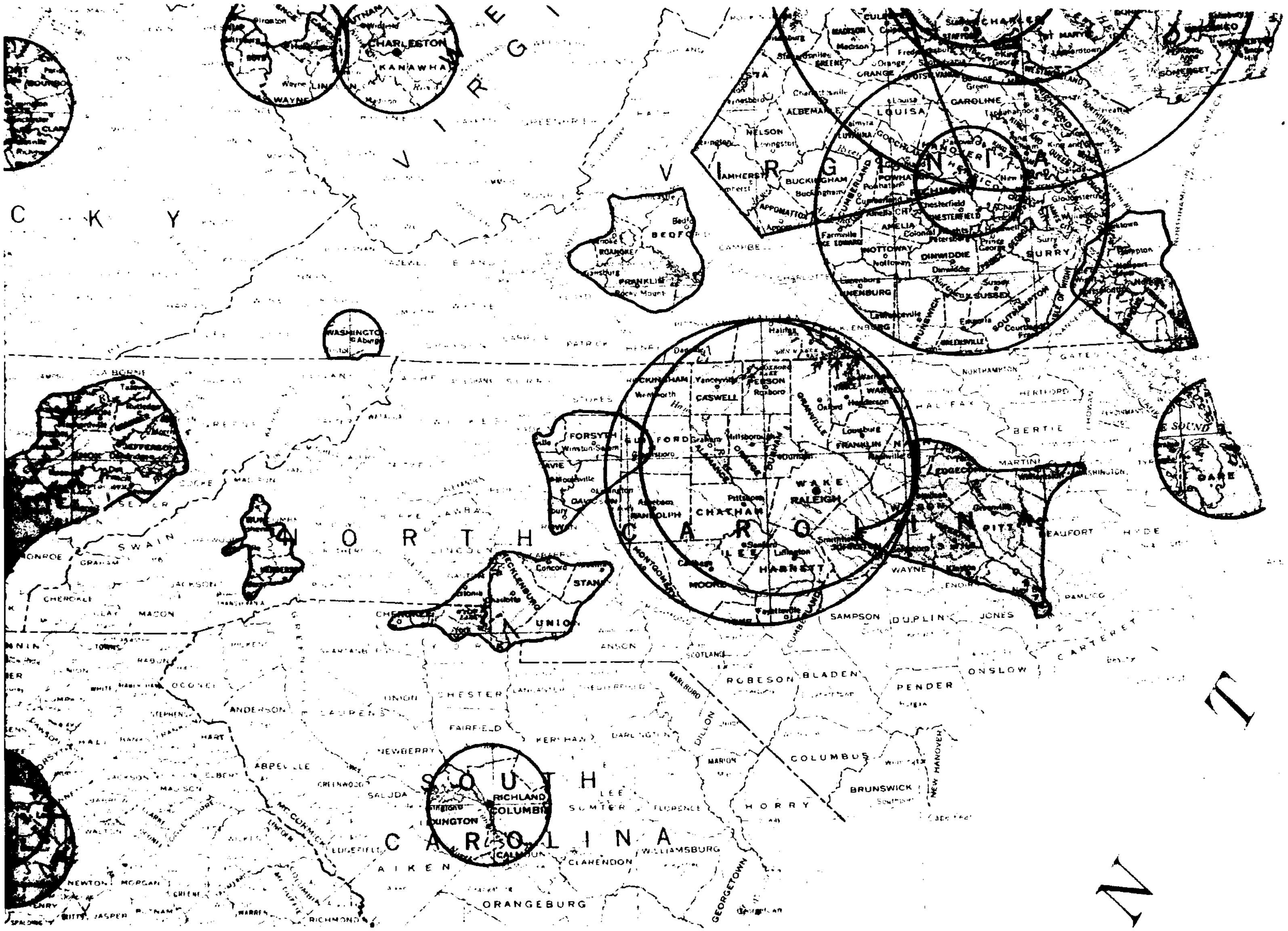


FIGURE A-41 LOCAL OPERATING AREA COVERAGE FOR NORTH CAROLINA

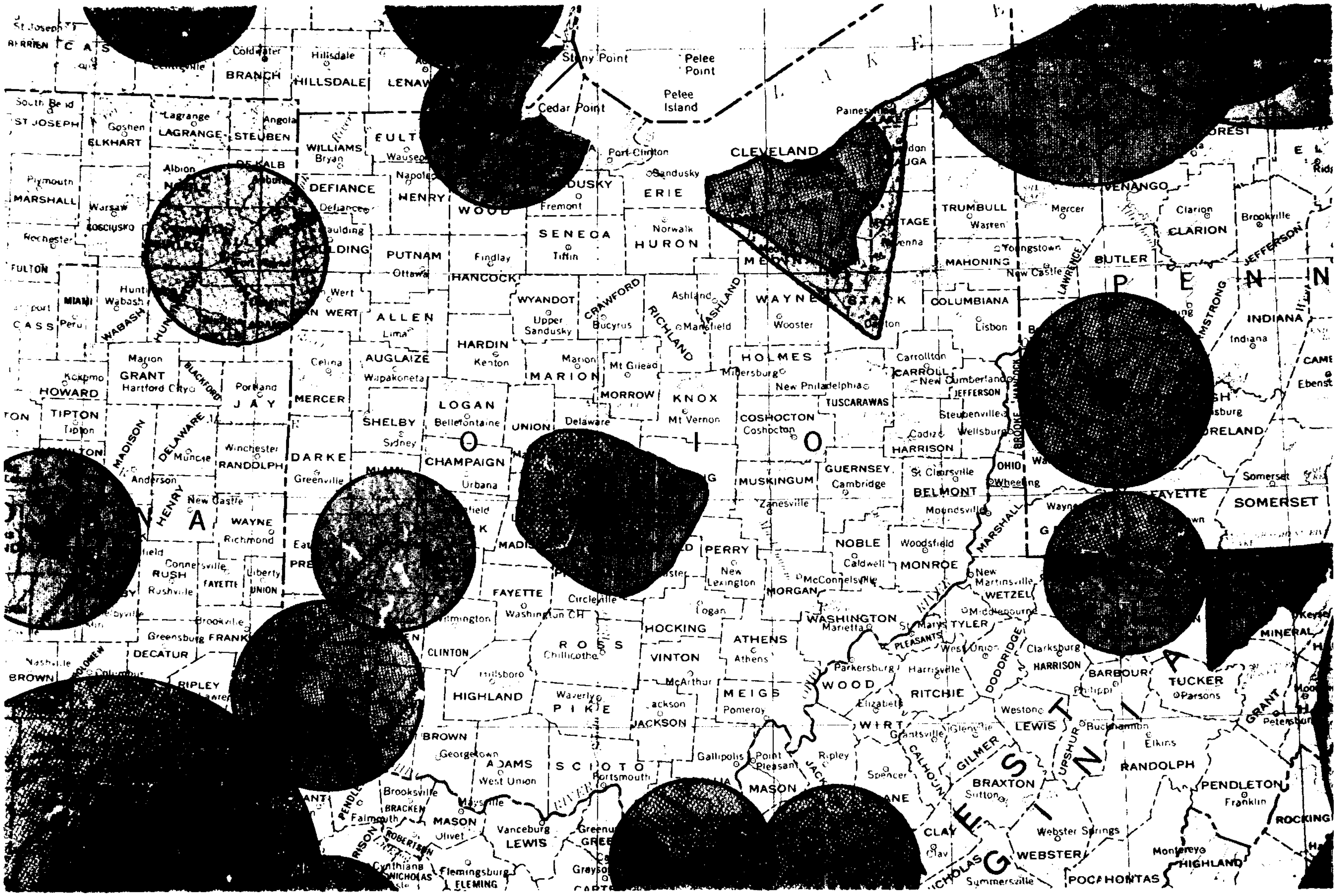


FIGURE A-42 LOCAL OPERATING AREA COVERAGE FOR OHIO

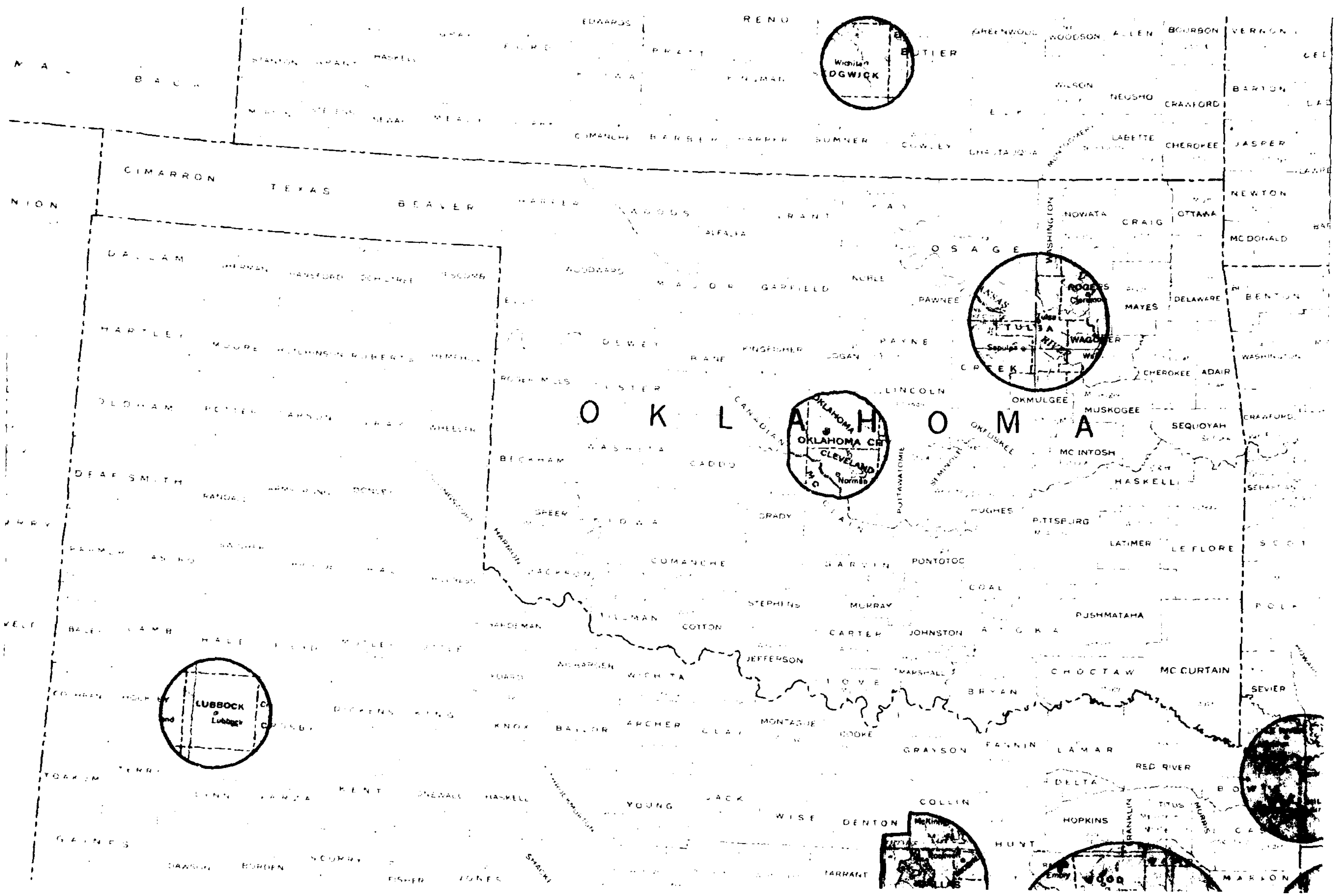


FIGURE A-43 LOCAL OPERATING AREA COVERAGE FOR OKLAHOMA

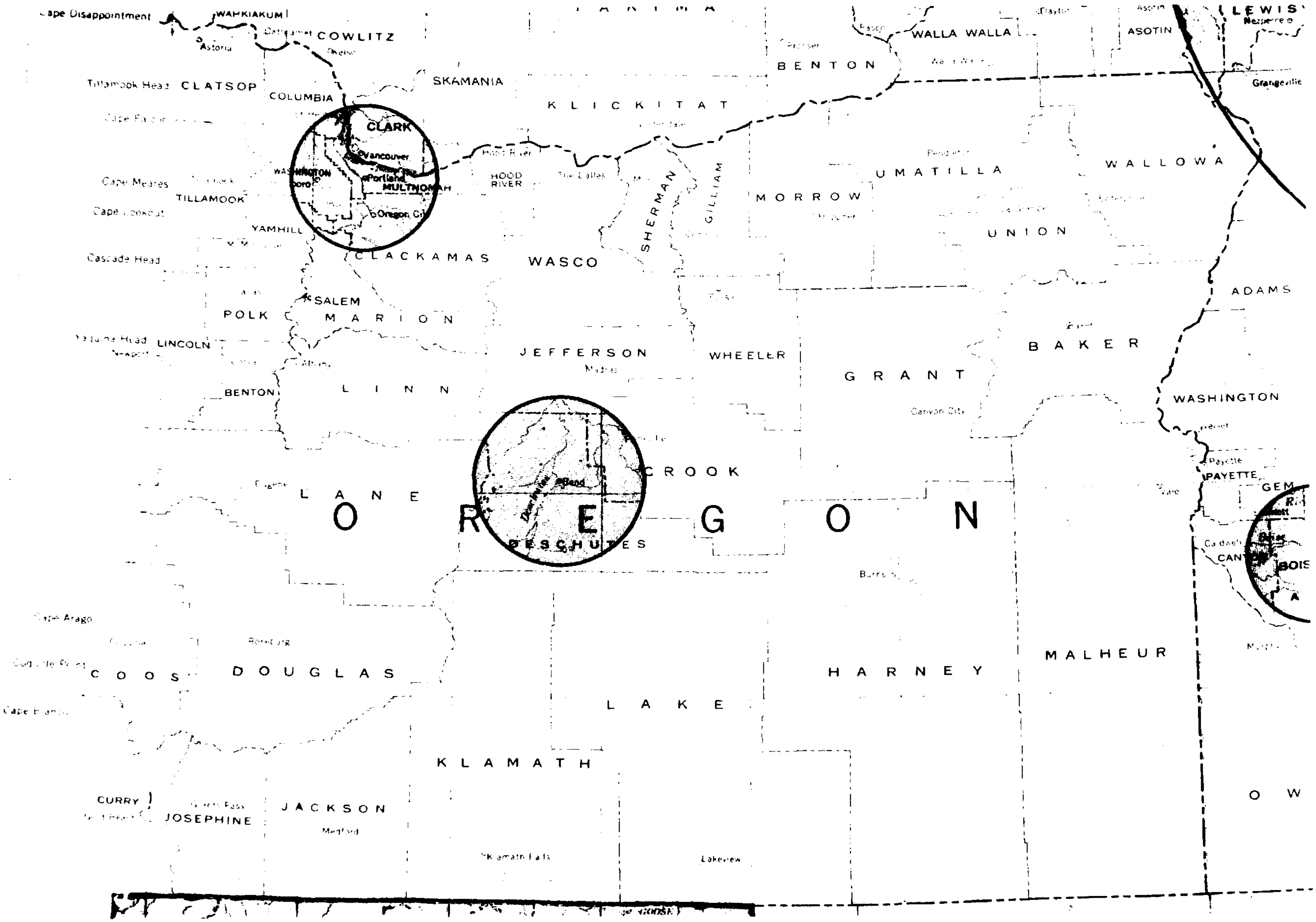


FIGURE A-44 LOCAL OPERATING AREA COVERAGE FOR OREGON

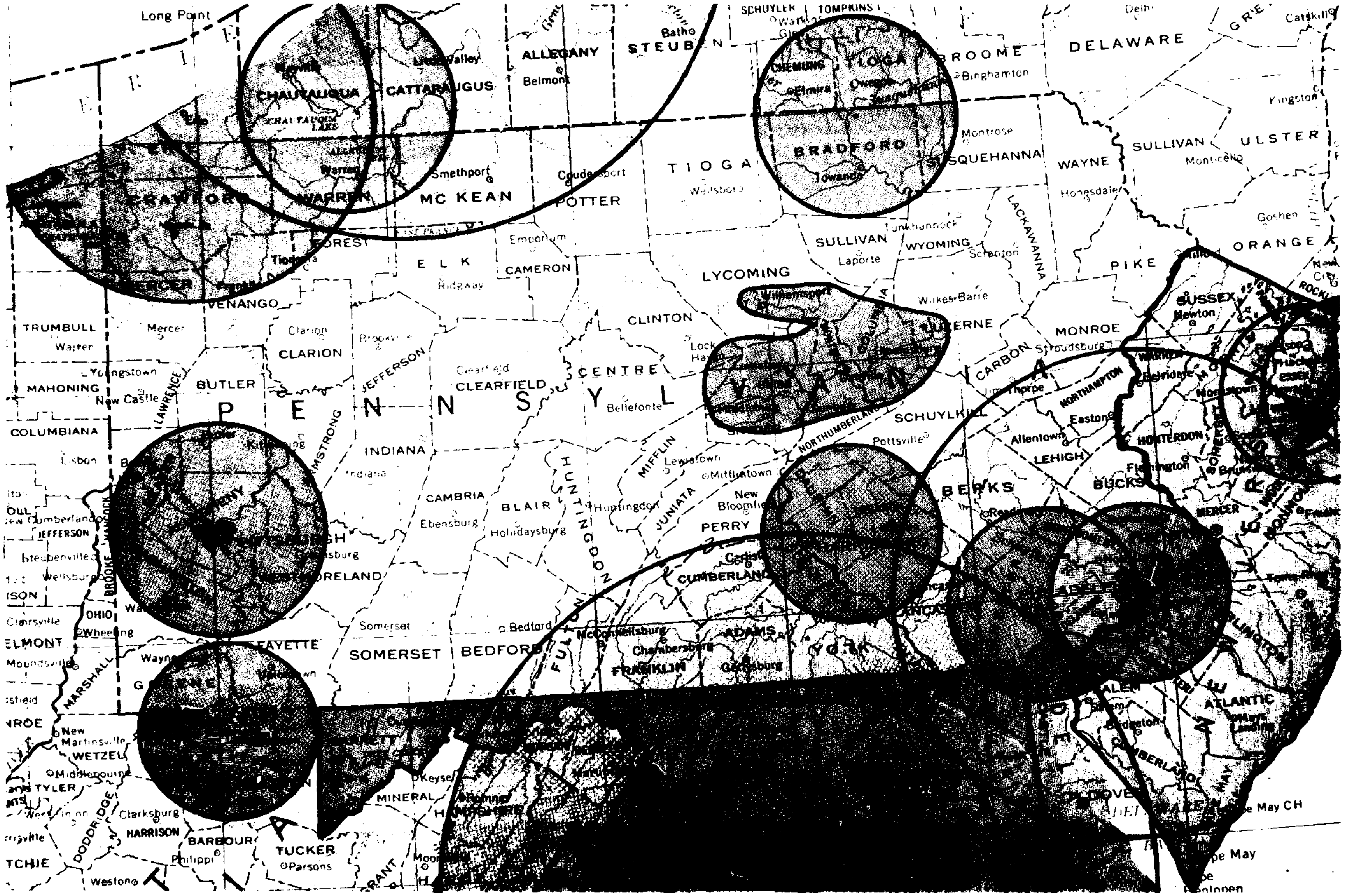


FIGURE A-45 LOCAL OPERATING AREA COVERAGE FOR PENNSYLVANIA

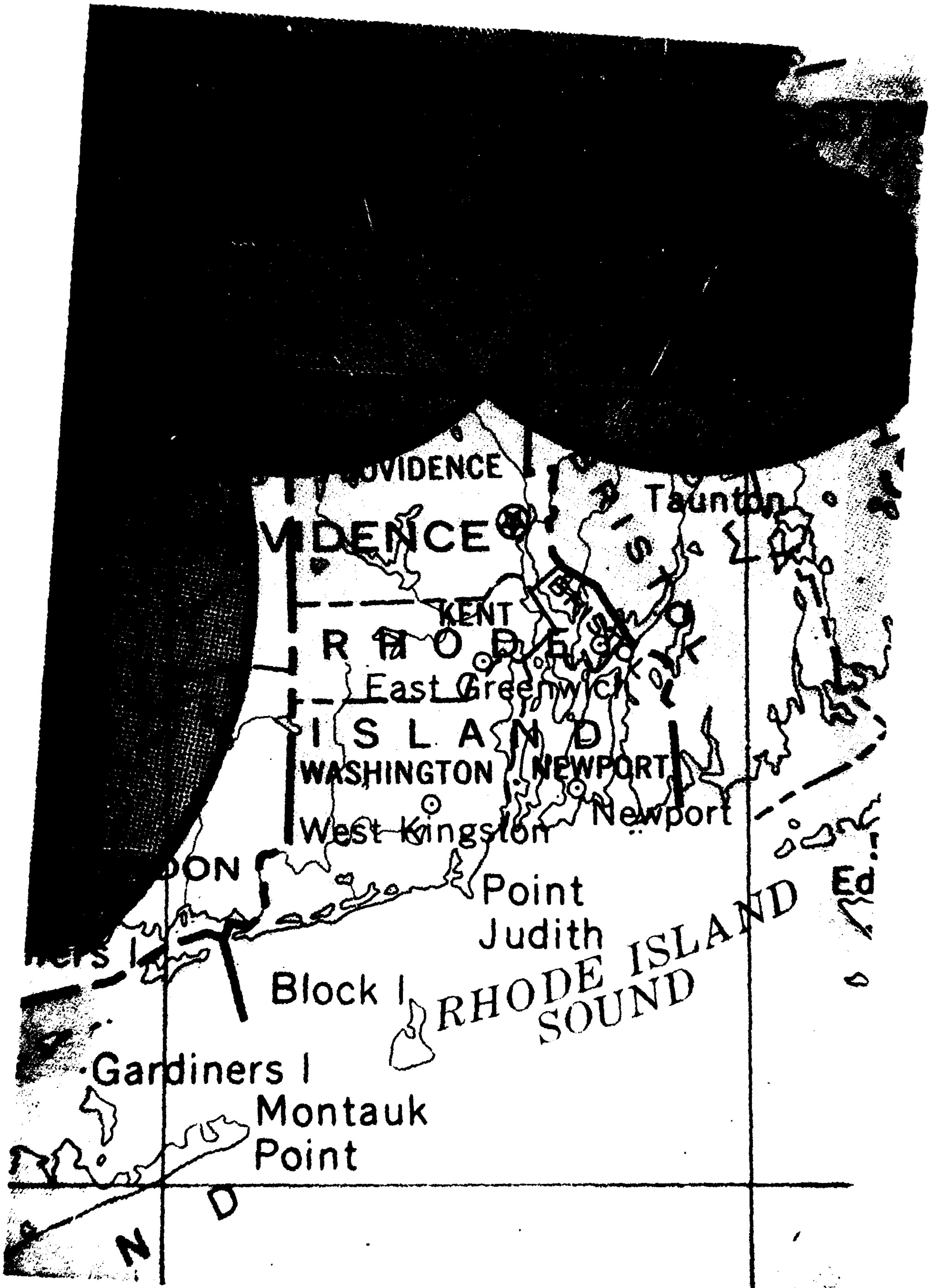


FIGURE A-46 LOCAL OPERATING AREA COVERAGE FOR RHODE ISLAND

FIGURE A-47 LOCAL OPERATING AREA COVERAGE FOR SOUTH CAROLINA

FIGURE A-48 LOCAL OPERATING AREA COVERAGE FOR SOUTH DAKOTA

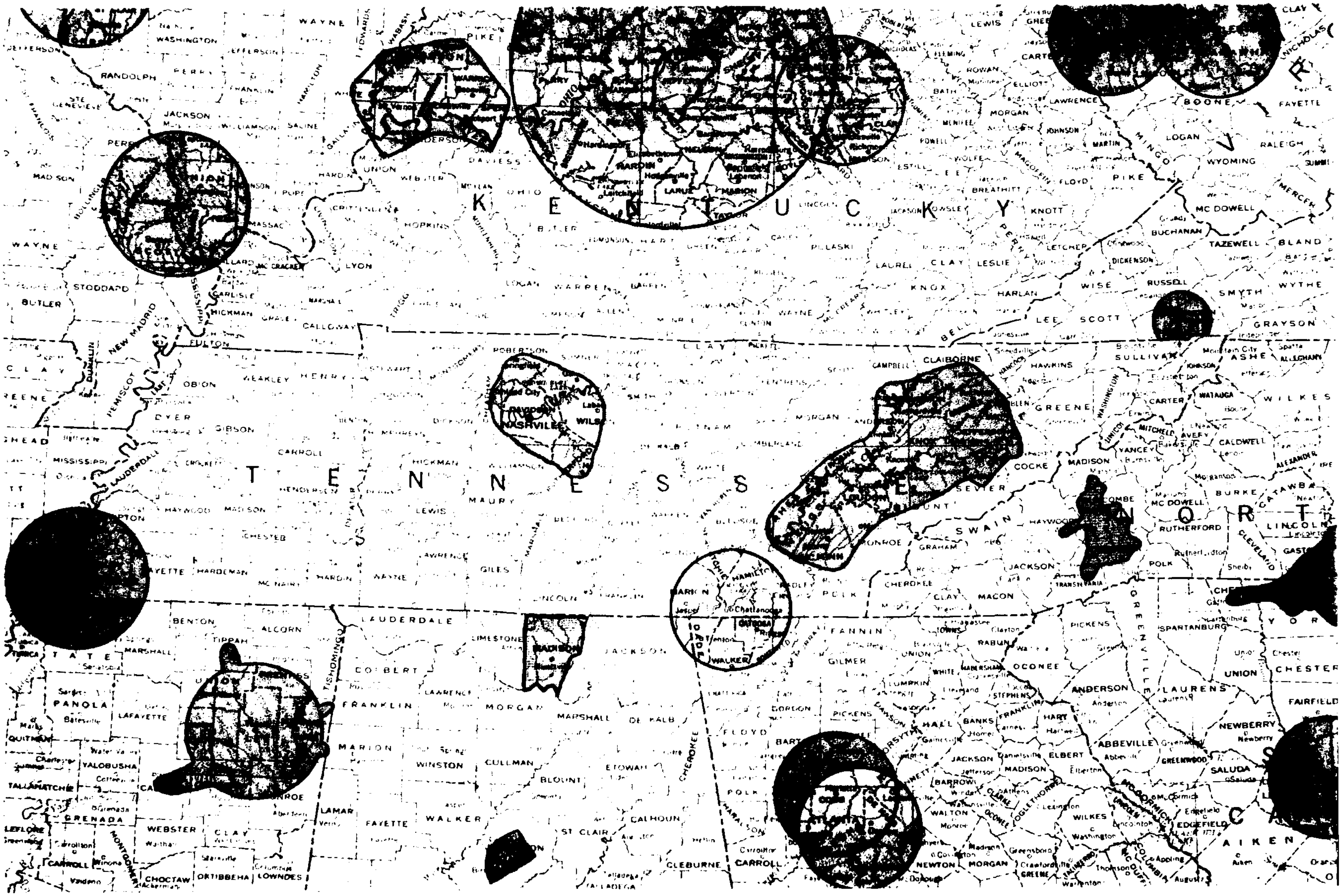


FIGURE A-49 LOCAL OPERATING AREA COVERAGE FOR TENNESSEE

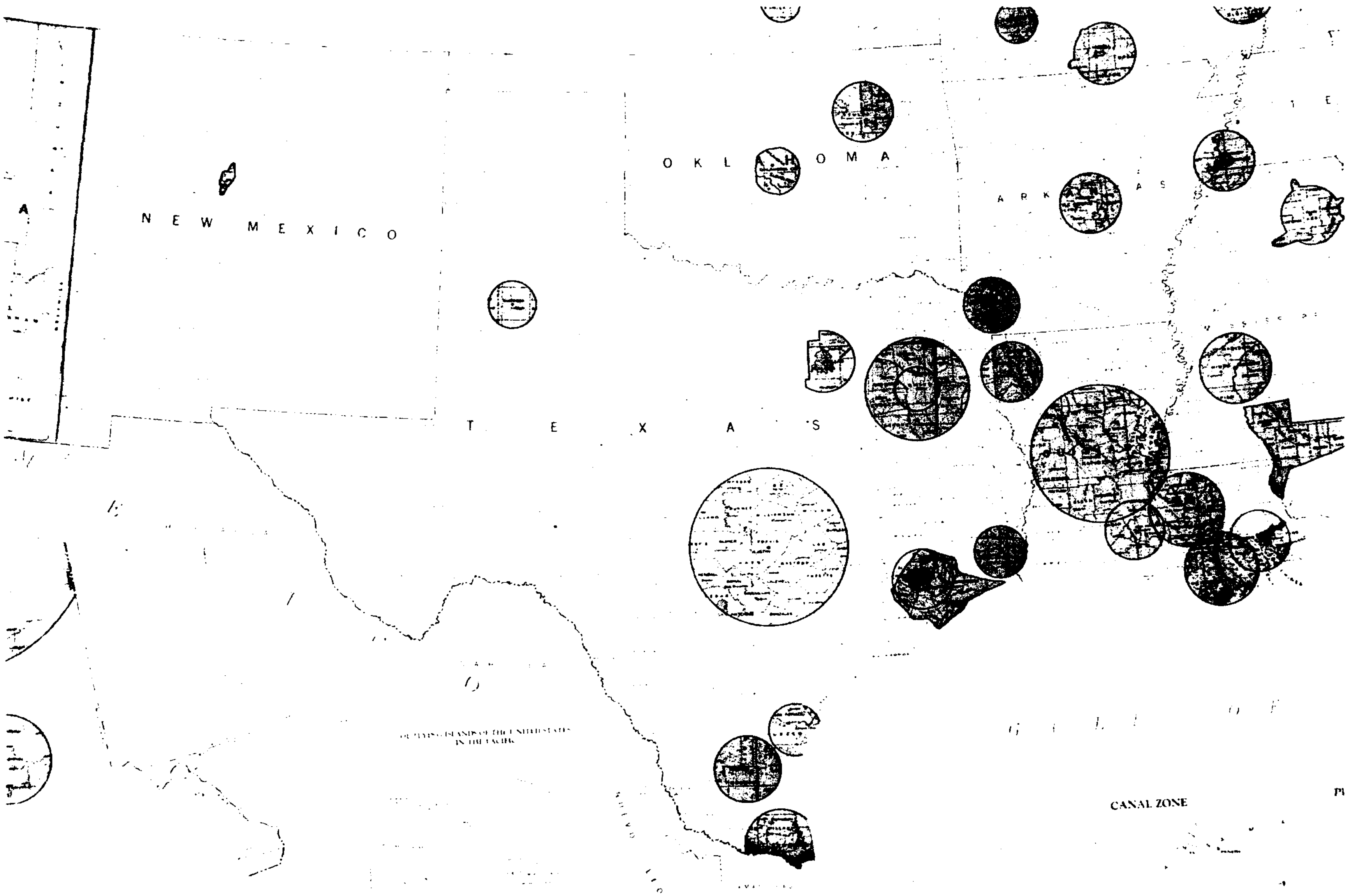


FIGURE A-50 LOCAL OPERATING AREA COVERAGE FOR TEXAS

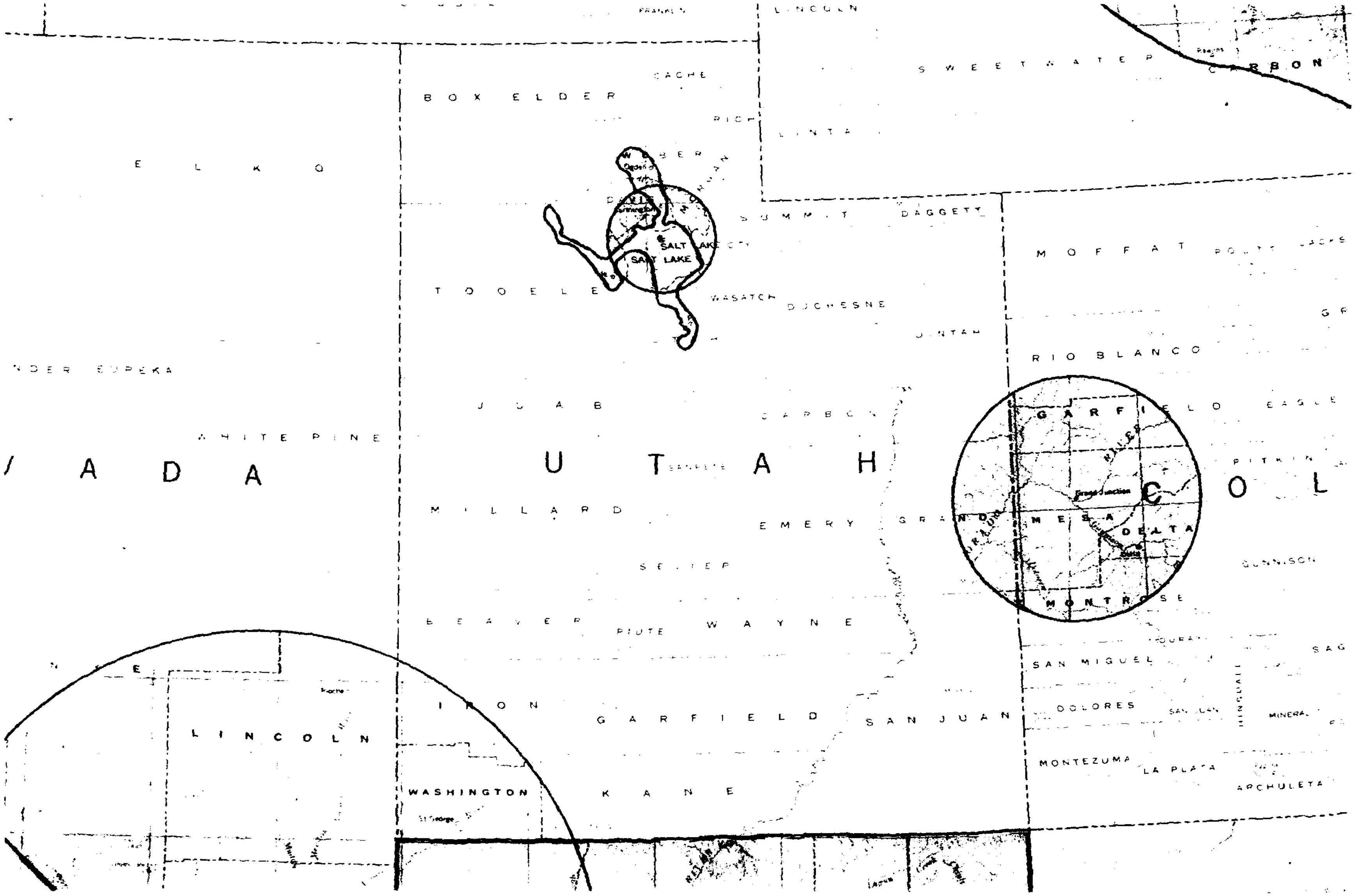


FIGURE A-51 LOCAL OPERATING AREA COVERAGE FOR UTAH

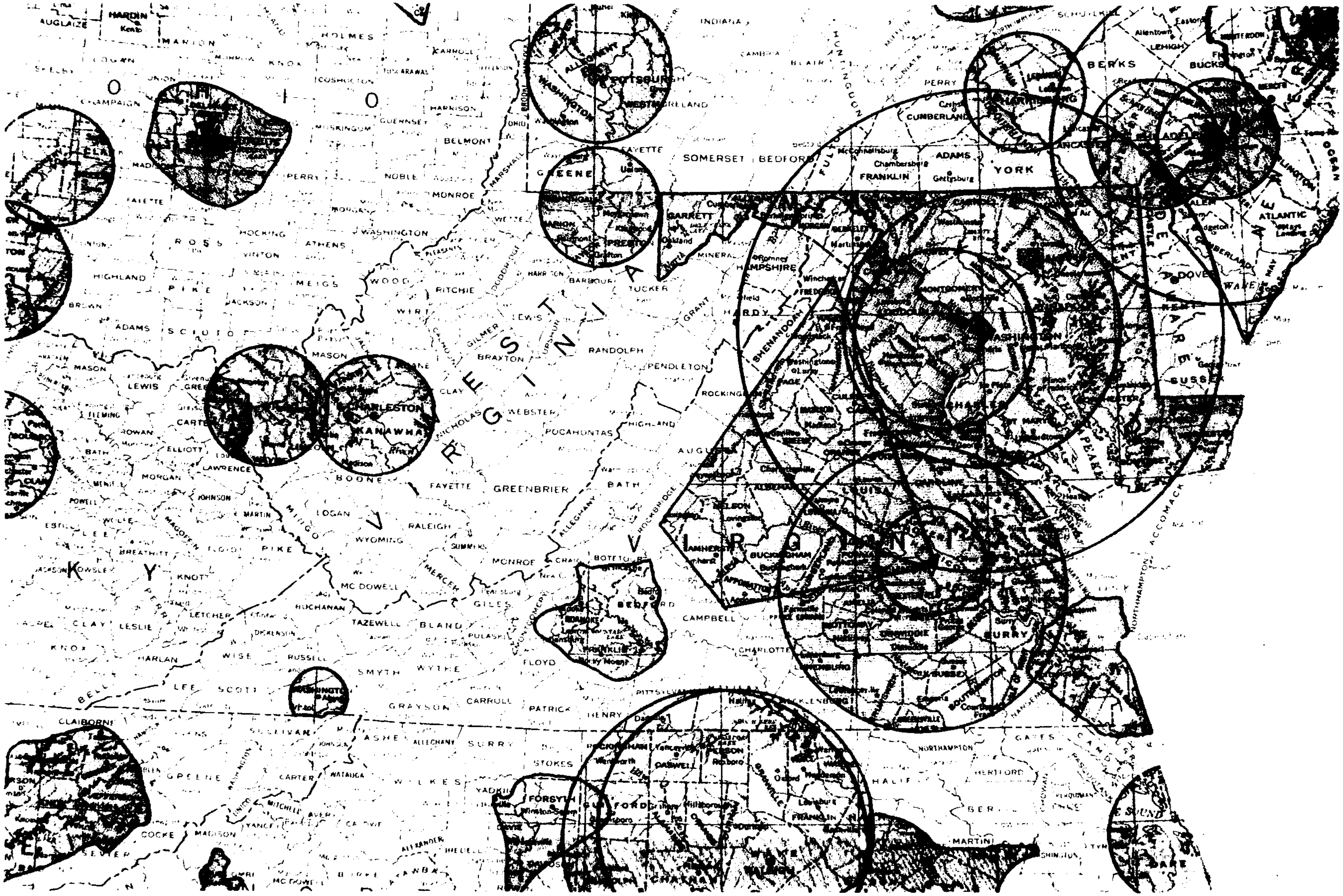


FIGURE A-52 LOCAL OPERATING AREA COVERAGE FOR VIRGINIA

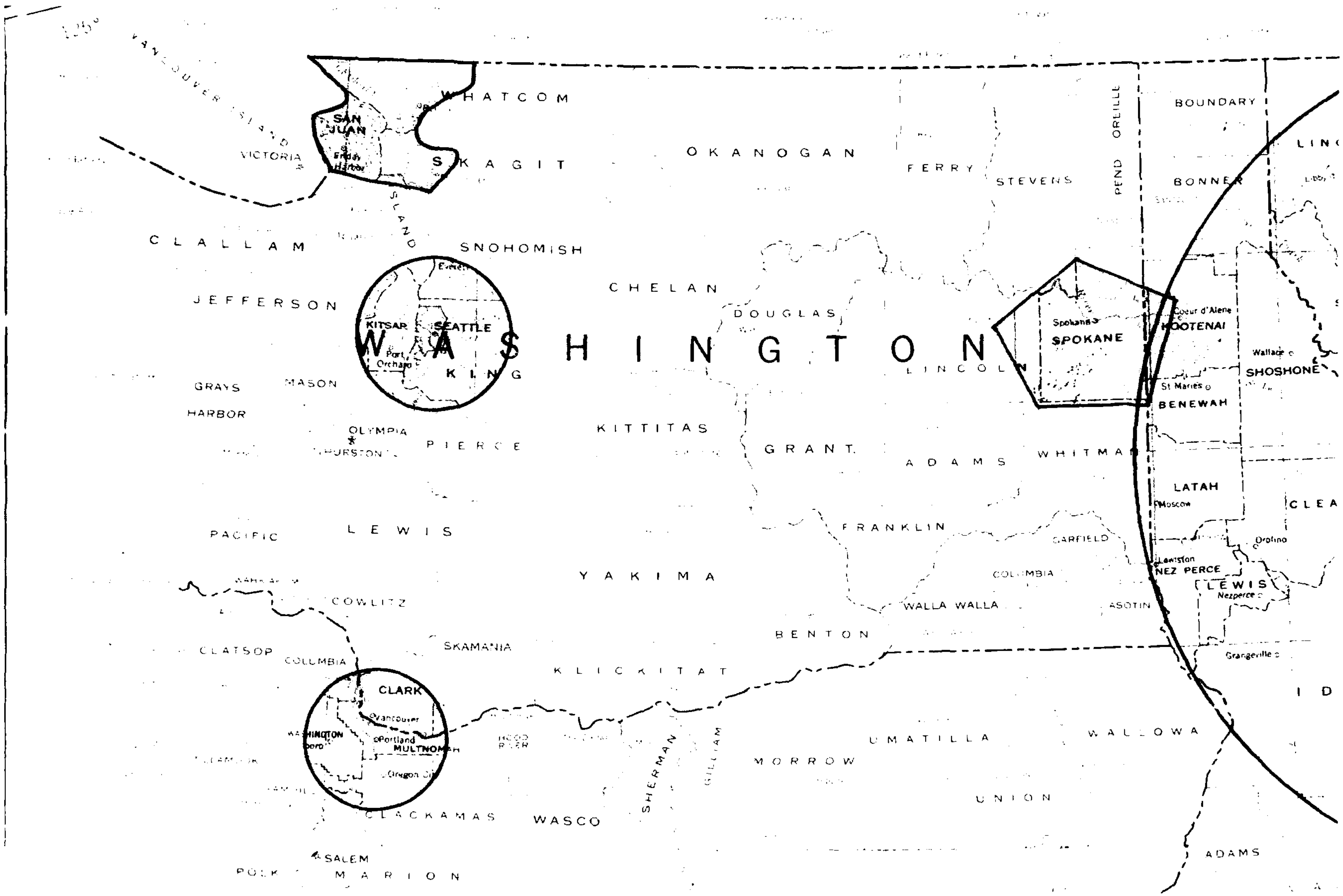


FIGURE A-53 LOCAL OPERATING AREA COVERAGE FOR WASHINGTON

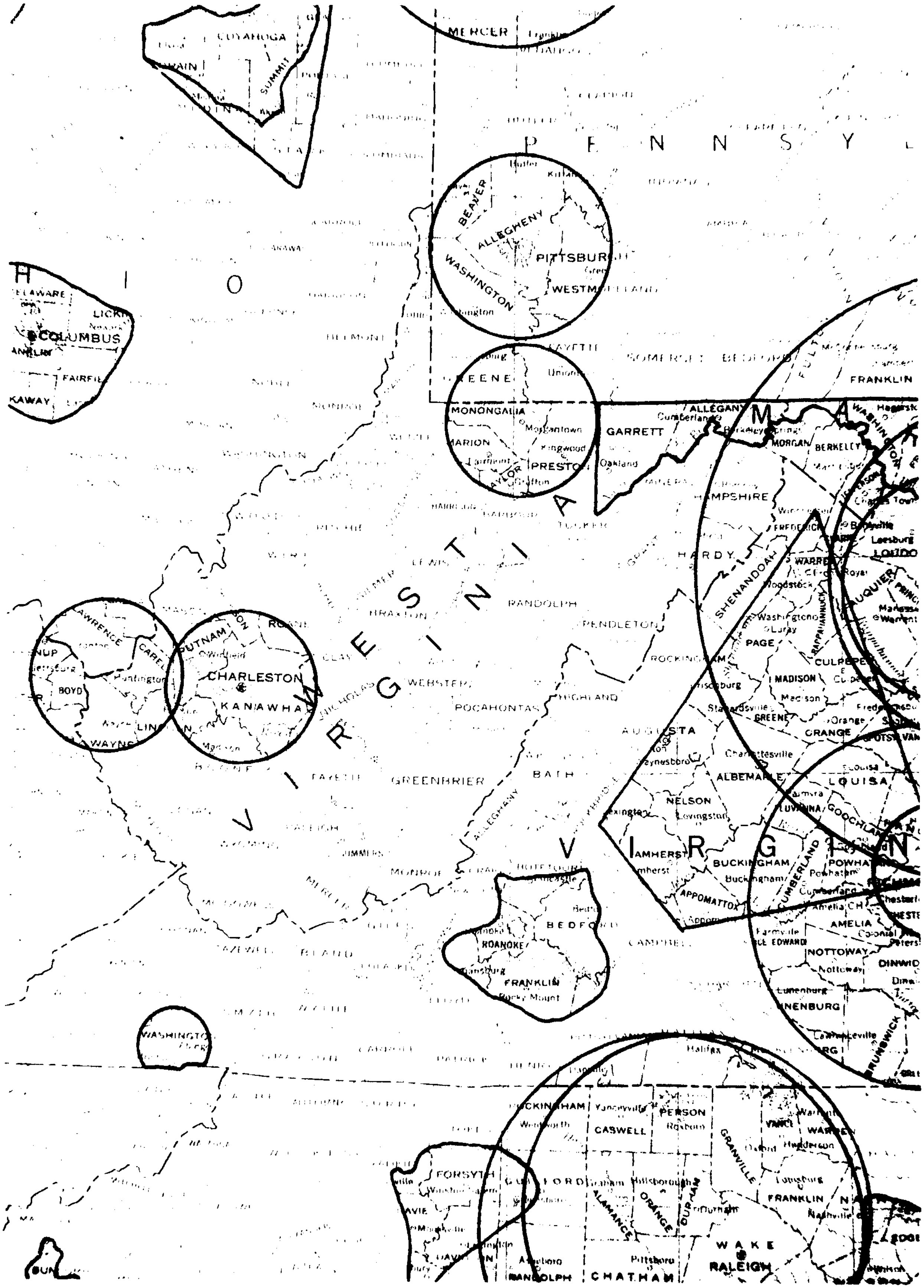


FIGURE A-54 LOCAL OPERATING AREA COVERAGE FOR WEST VIRGINIA

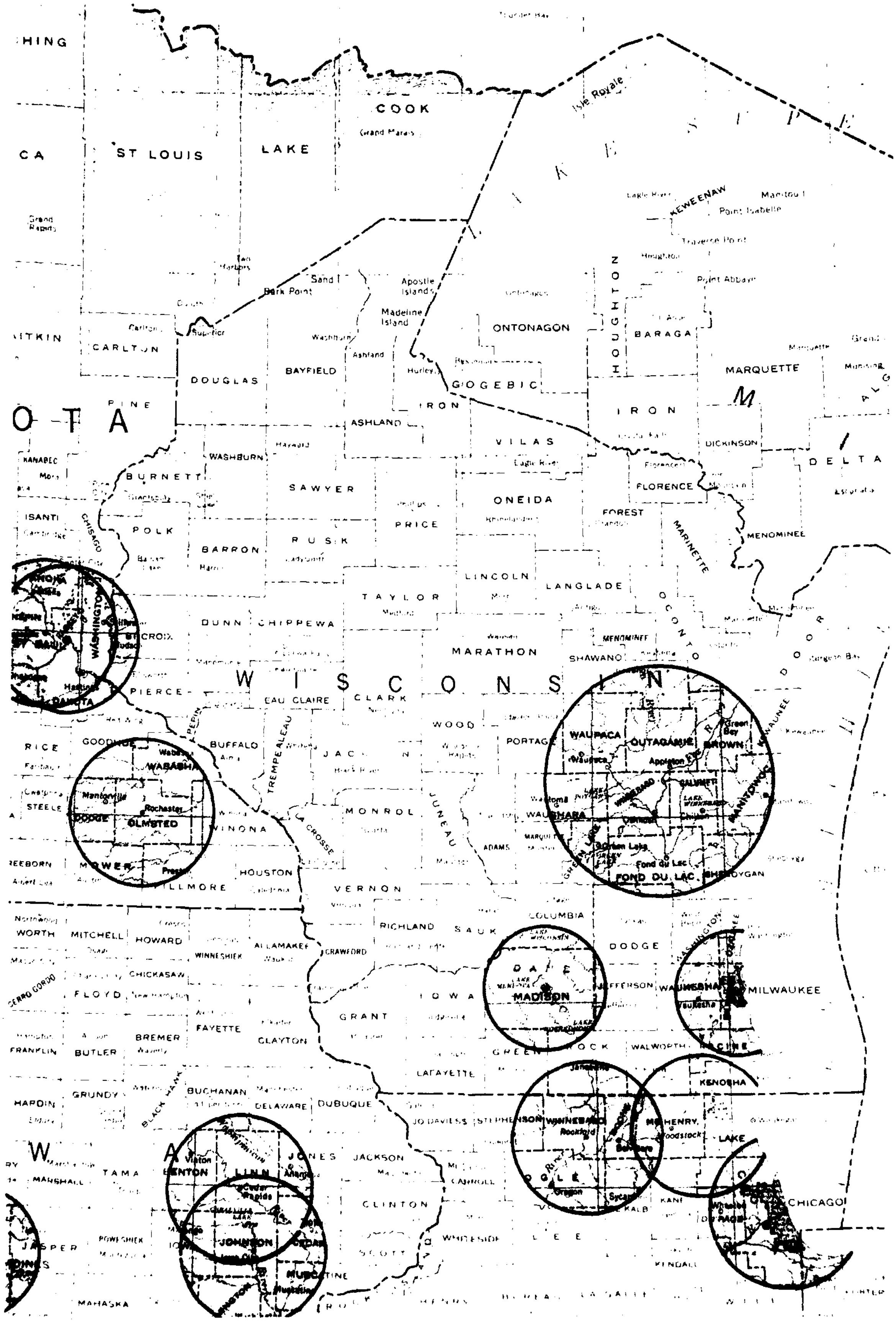


FIGURE A-55 LOCAL OPERATING AREA COVERAGE FOR WISCONSIN

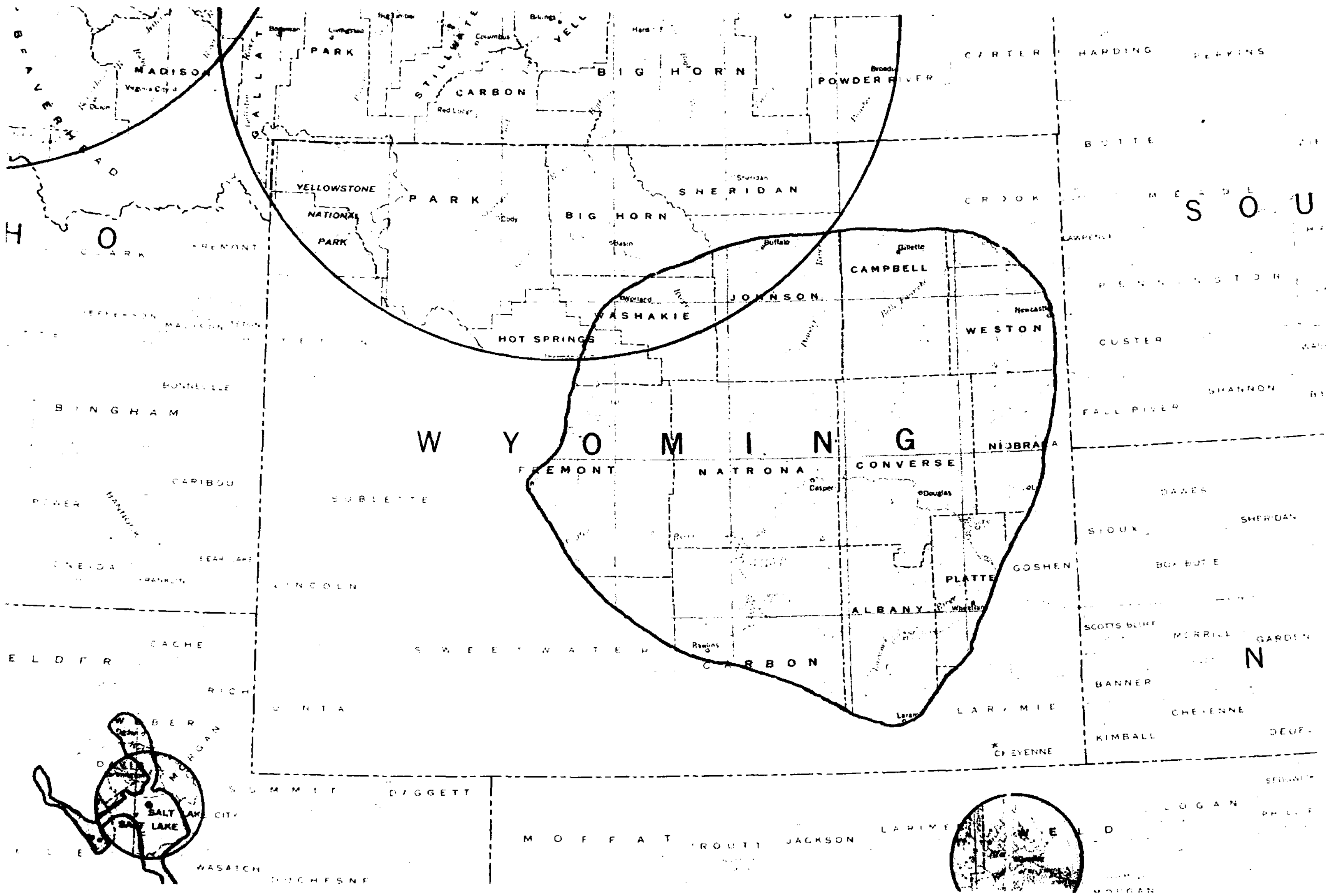


FIGURE A-56 LOCAL OPERATING AREA COVERAGE FOR WYOMING

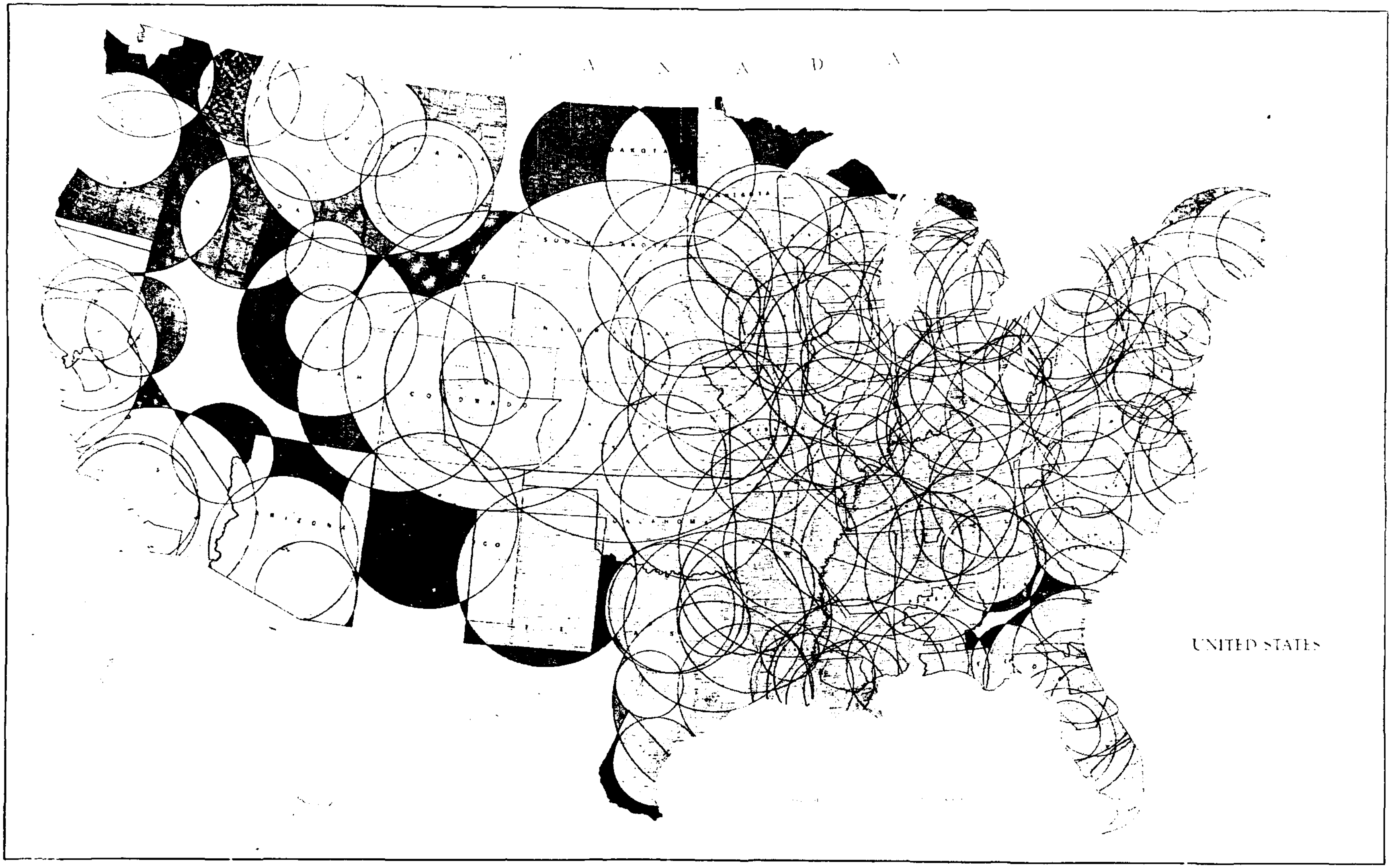


FIGURE A-57 CROSS COUNTRY OPERATING AREA COVERAGE FOR THE CONTERMINOUS UNITED STATES

FIGURE A-58 CROSS COUNTRY OPERATING AREA COVERAGE FOR THE NEW ENGLAND REGION

FIGURE A-59 CROSS COUNTRY OPERATING AREA COVERAGE FOR THE EASTERN REGION

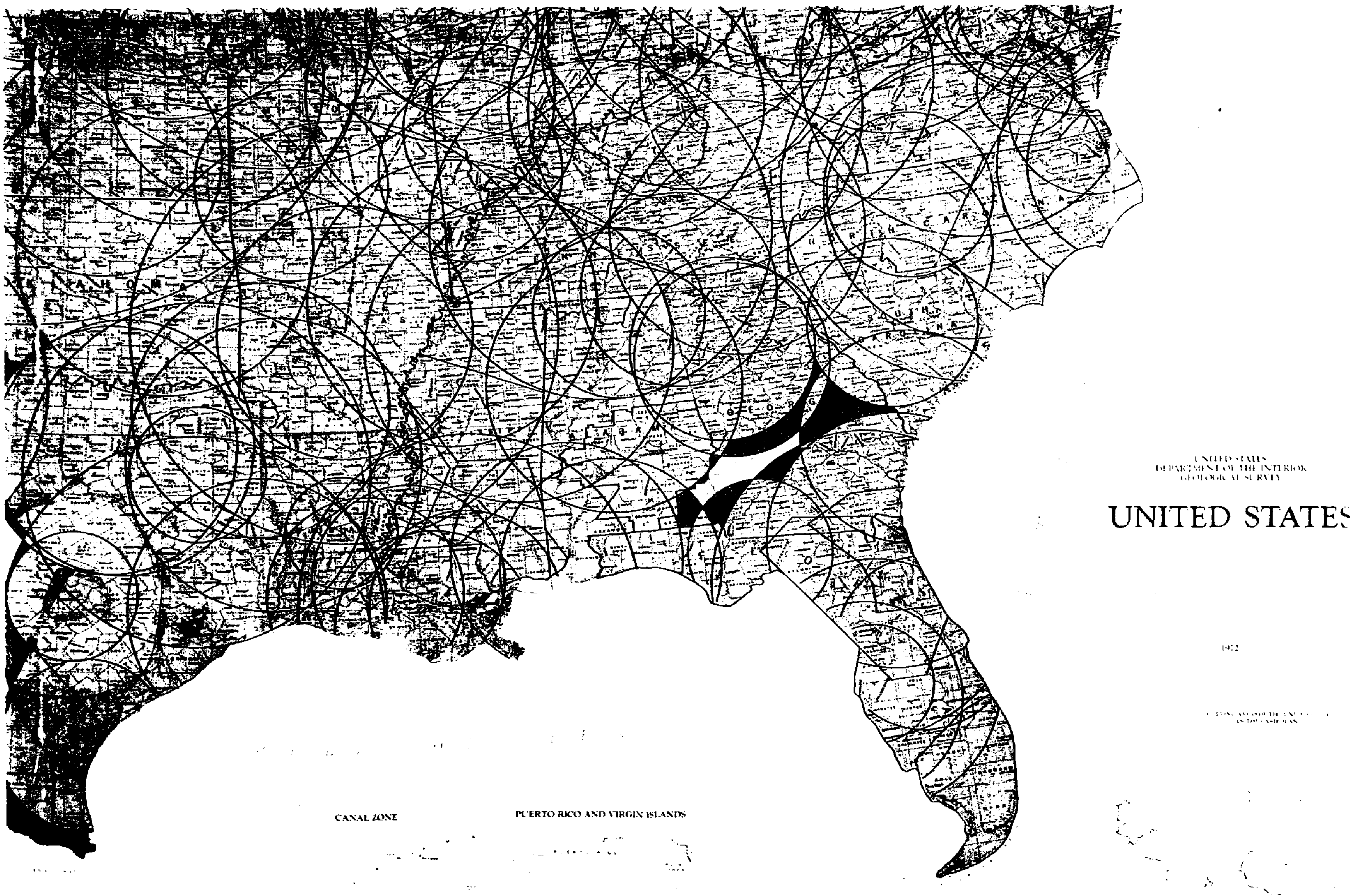


FIGURE A-60 CROSS COUNTRY OPERATING AREA COVERAGE FOR THE SOUTHERN REGION

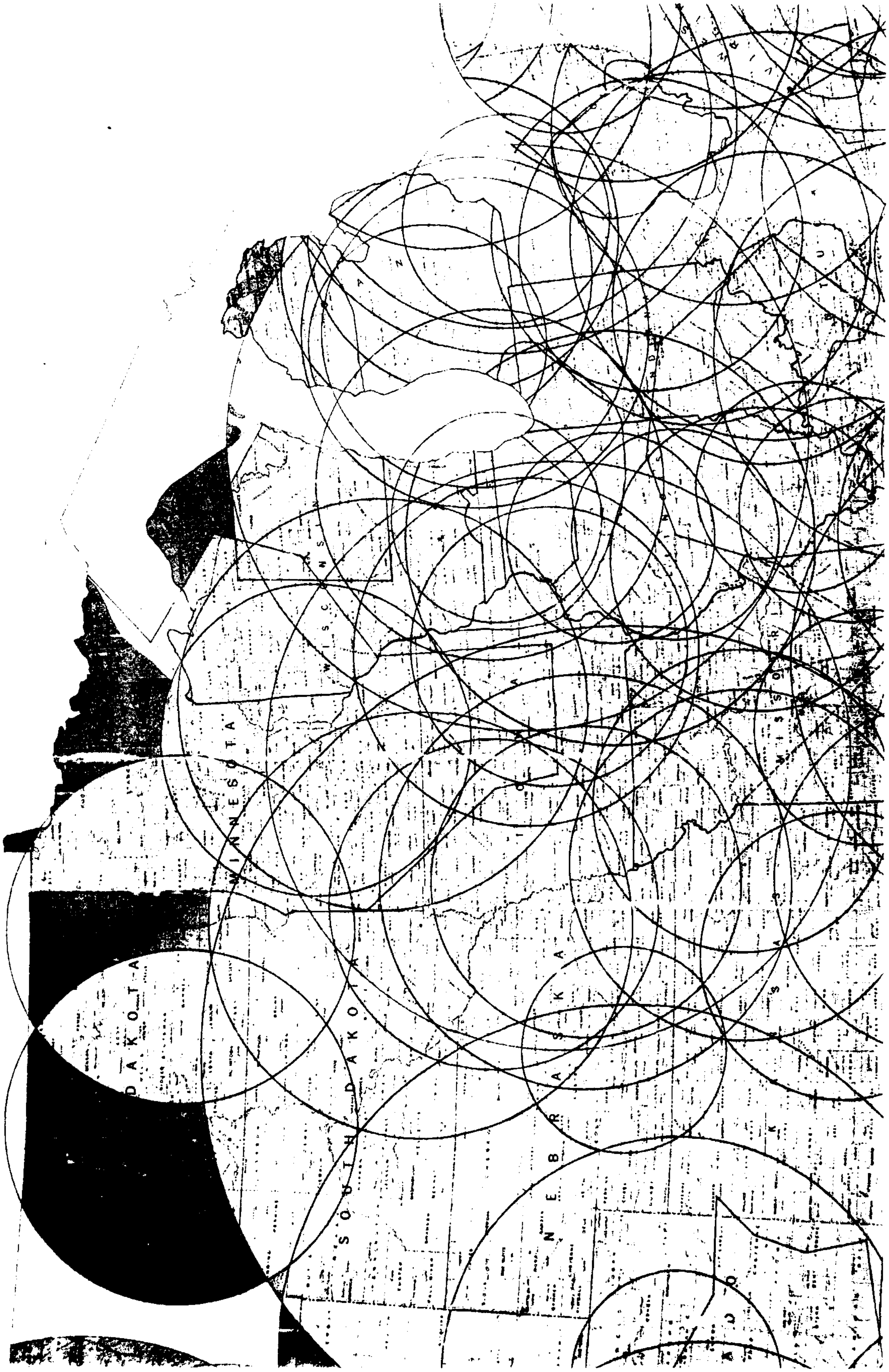


FIGURE A-61 CROSS COUNTRY OPERATING AREA COVERAGE FOR THE GREAT LAKES REGION

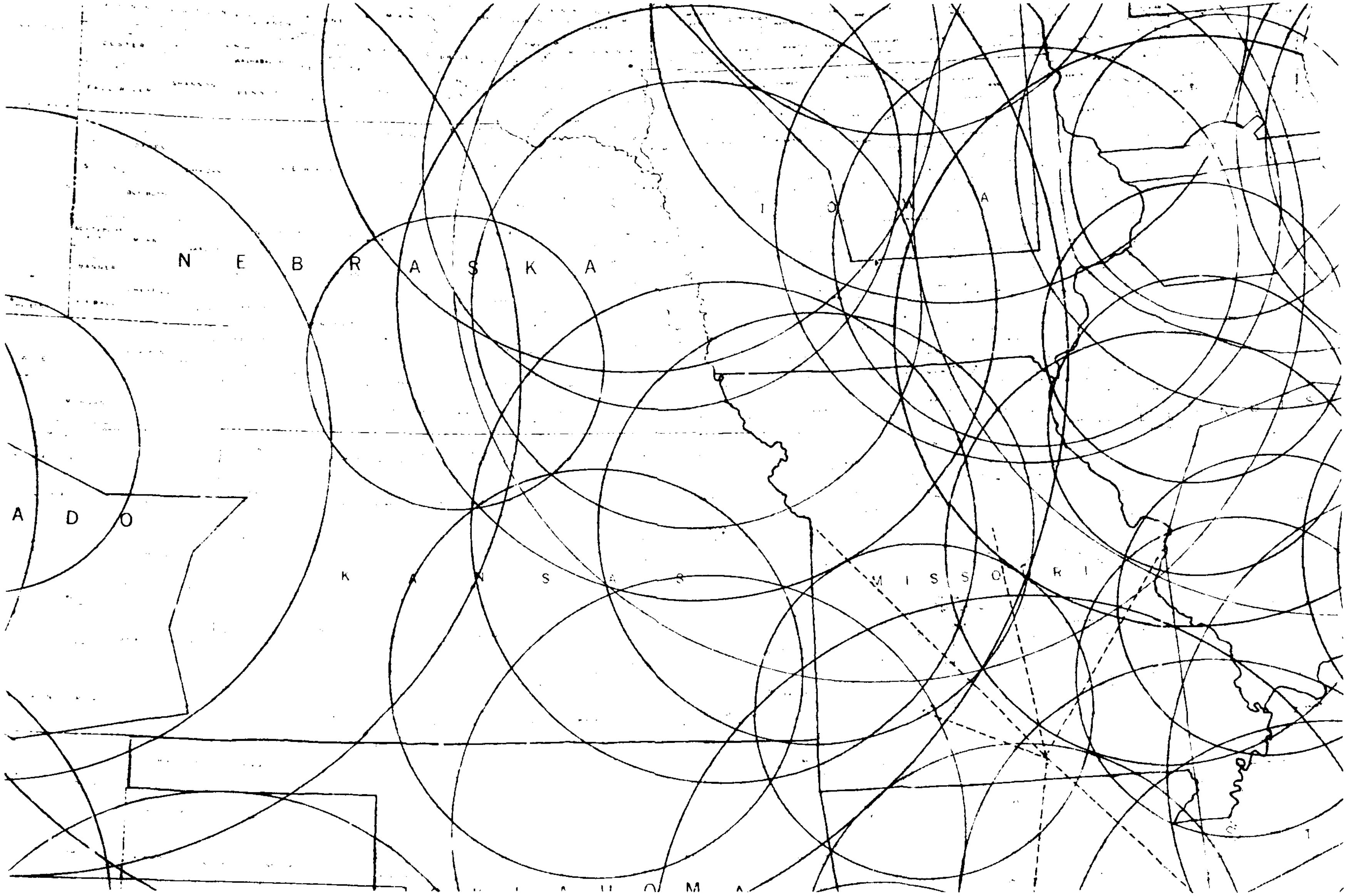


FIGURE A-62 CROSS COUNTRY OPERATING AREA COVERAGE FOR THE CENTRAL REGION

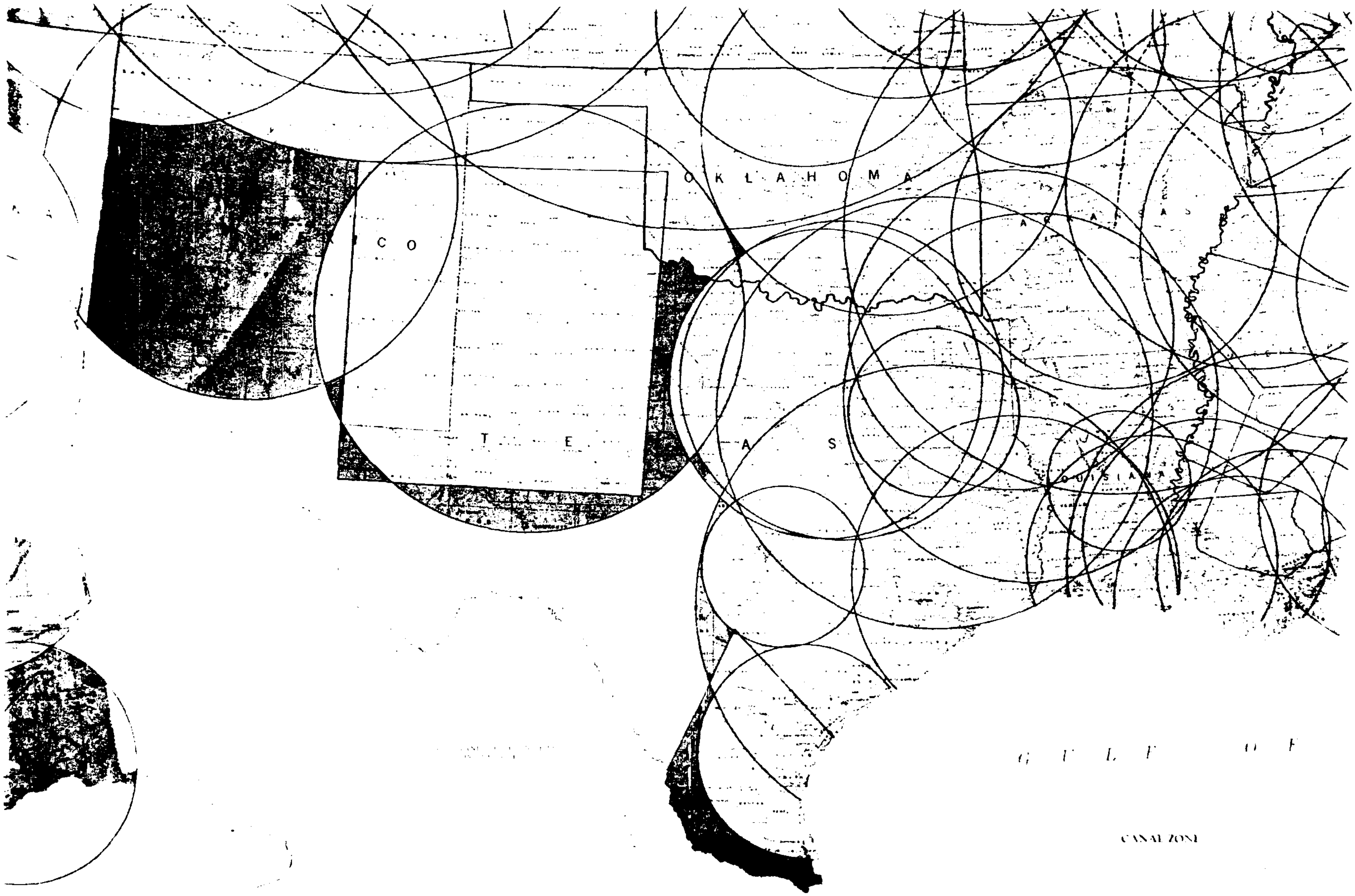


FIGURE A-63 CROSS COUNTRY OPERATING AREA COVERAGE FOR THE SOUTHWEST REGION

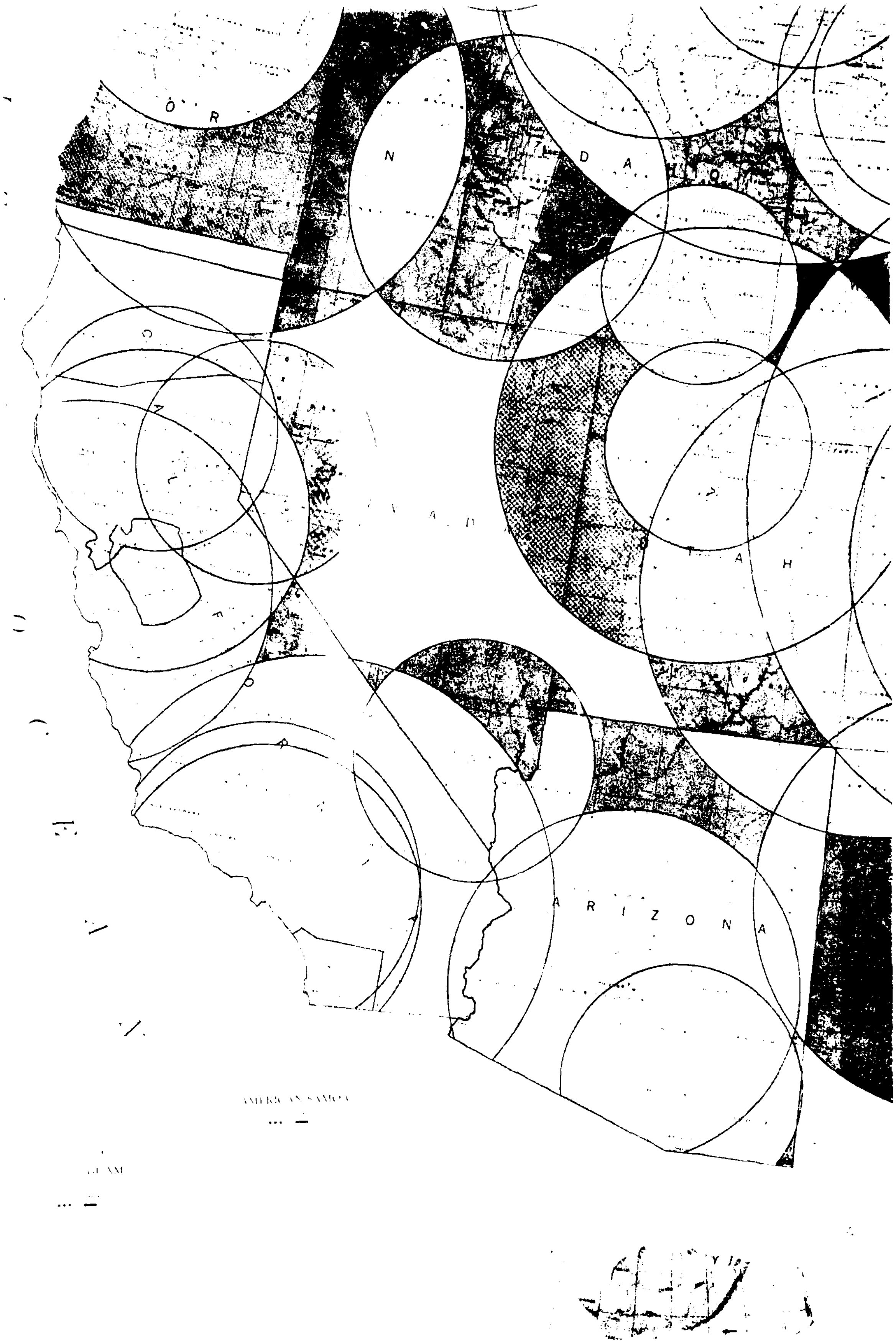


FIGURE A-64 CROSS COUNTRY OPERATING AREA COVERAGE FOR THE WESTERN PACIFIC REGION

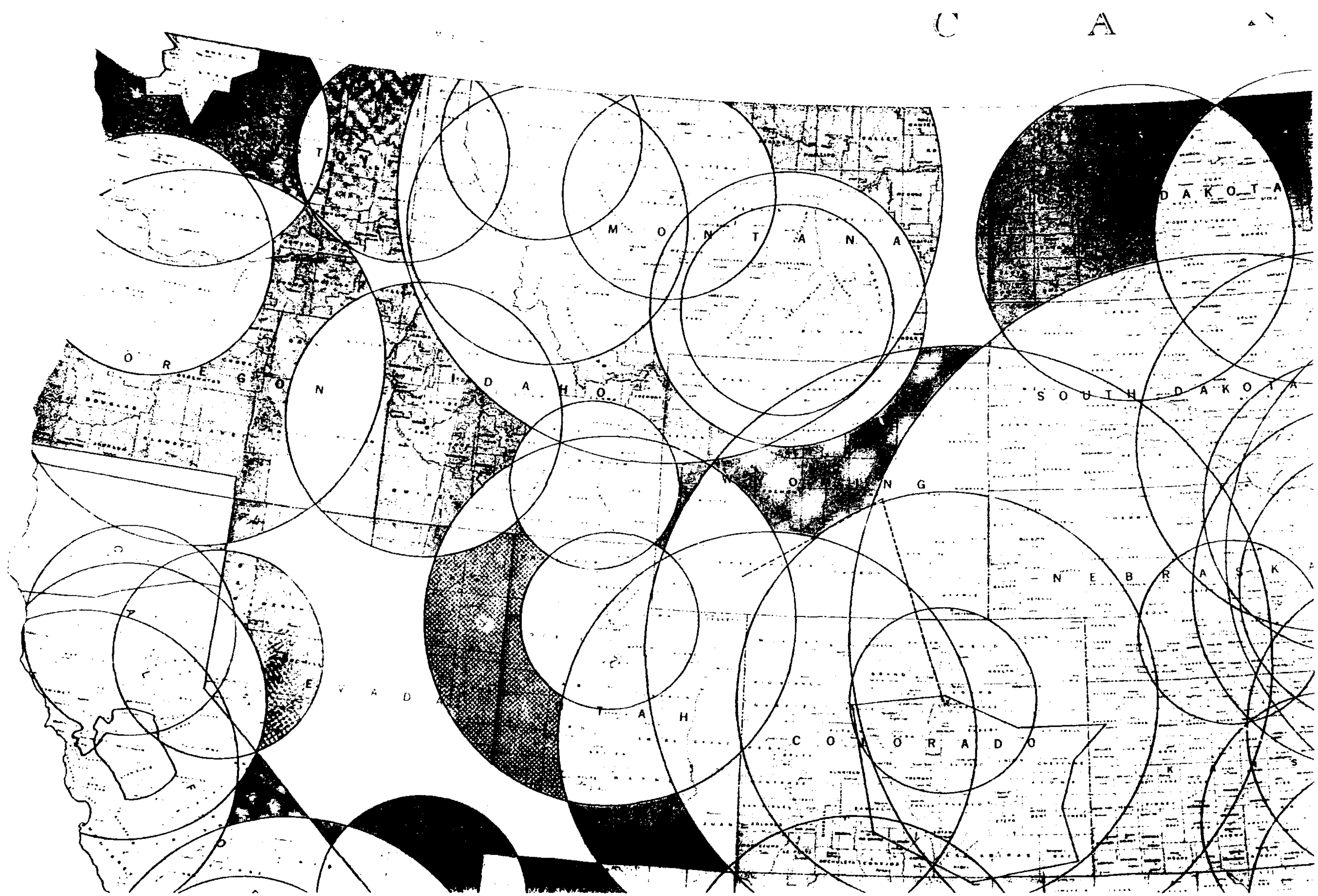


FIGURE A-65 CROSS COUNTRY OPERATING AREA COVERAGE FOR THE NORTHWEST MOUNTAIN REGION

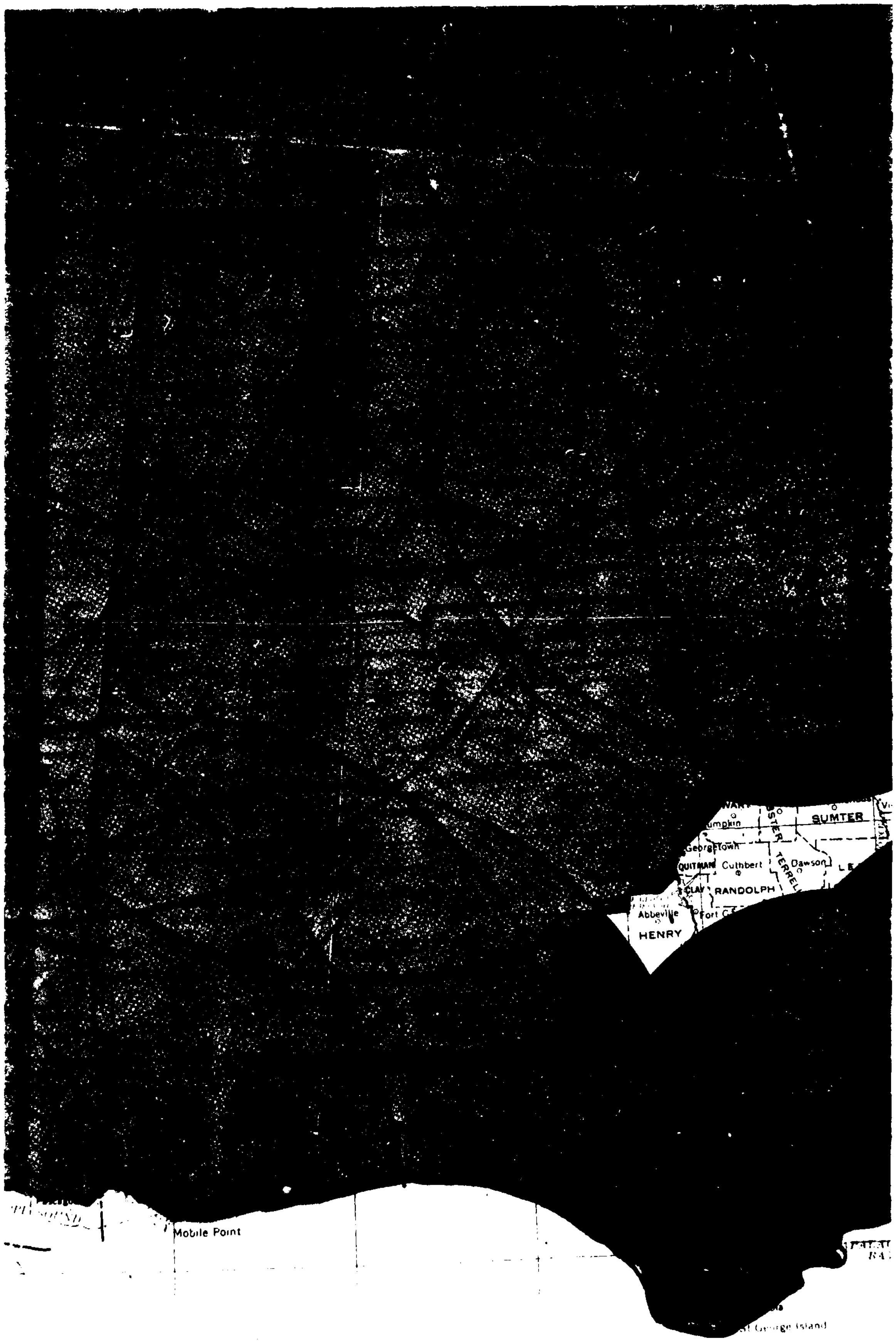


FIGURE A-66 CROSS COUNTRY OPERATING AREA COVERAGE FOR ALABAMA

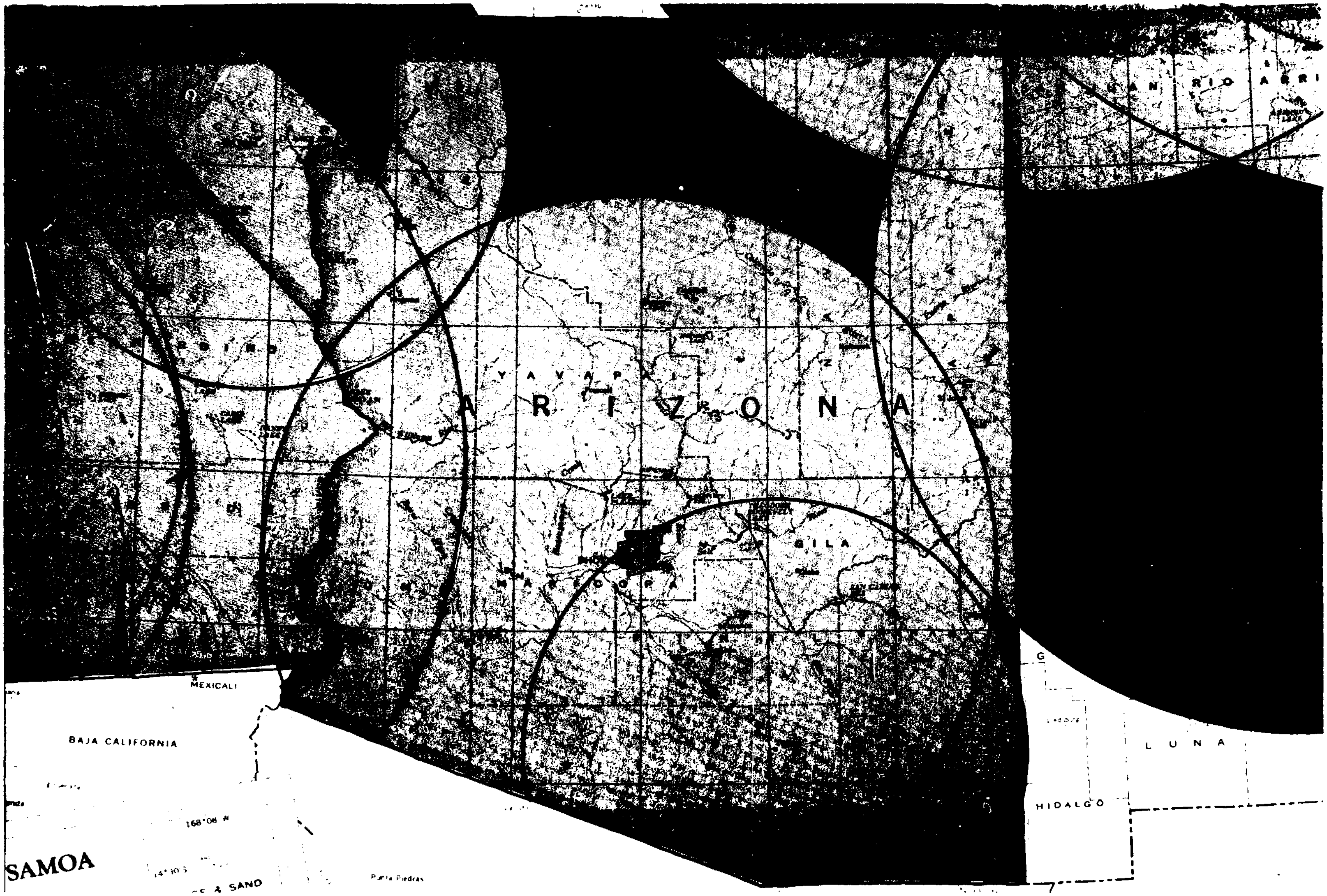


FIGURE A-67 CROSS COUNTRY OPERATING AREA COVERAGE FOR ARIZONA

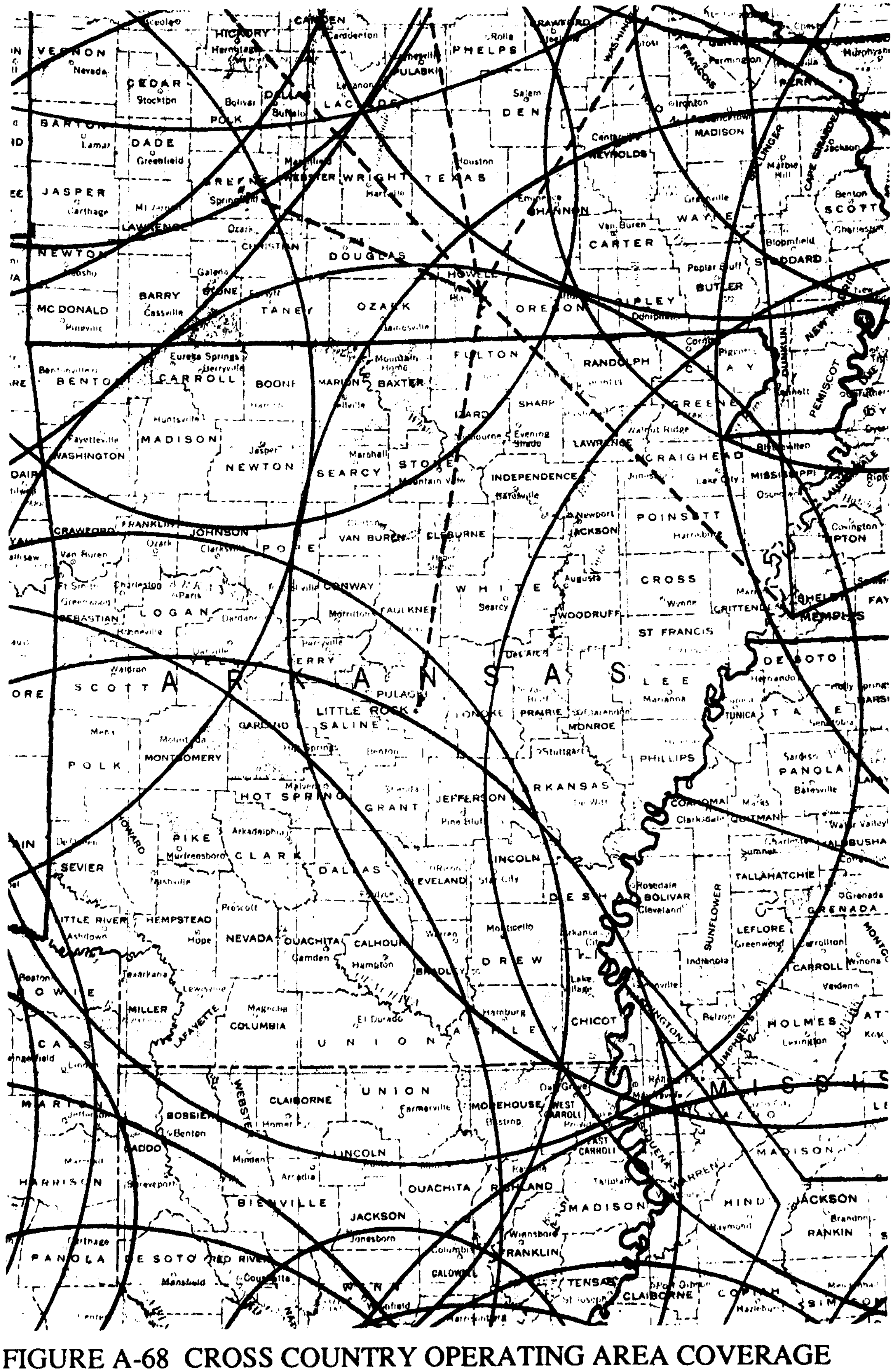


FIGURE A-68 CROSS COUNTRY OPERATING AREA COVERAGE FOR ARKANSAS

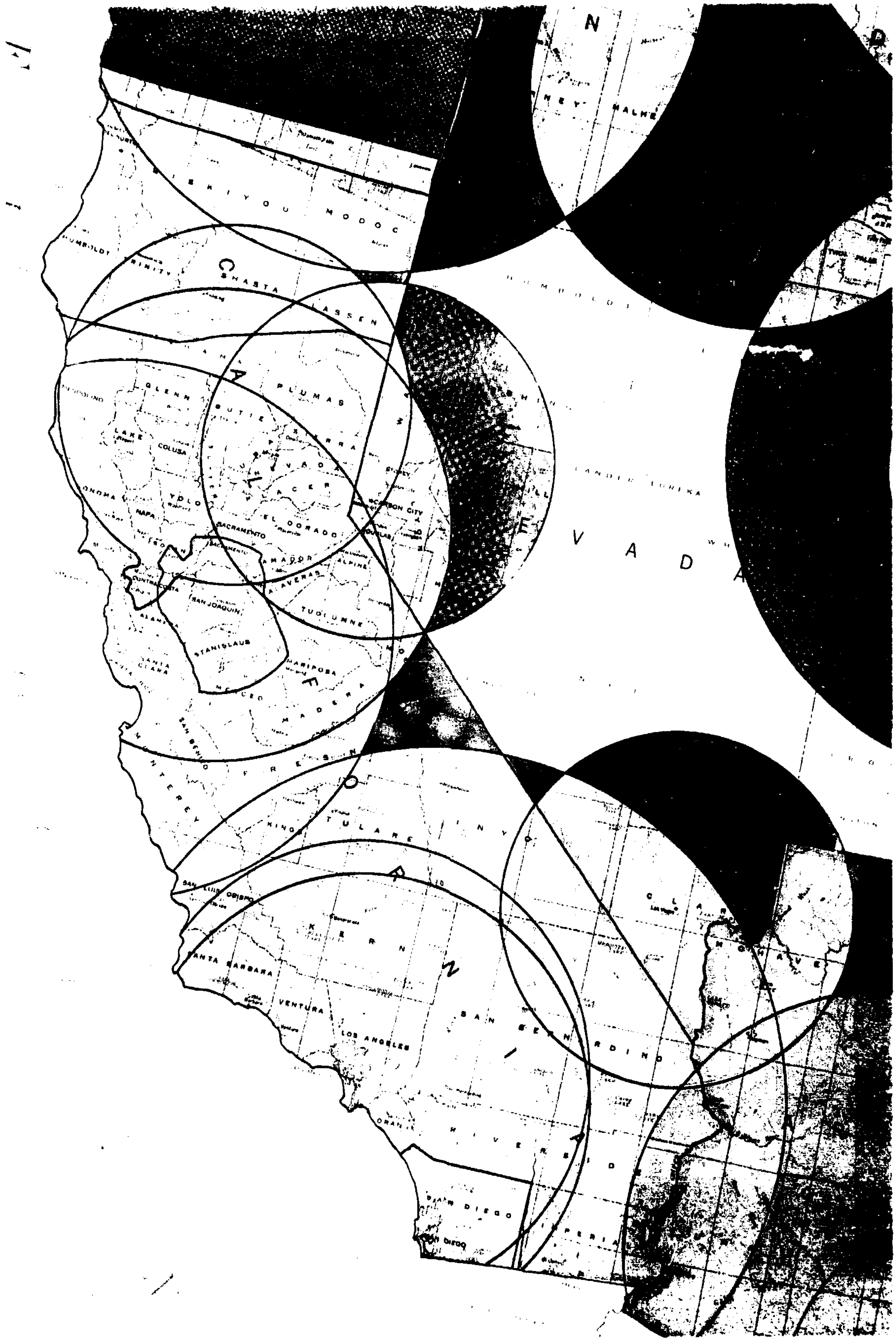


FIGURE A-69 CROSS COUNTRY OPERATING AREA COVERAGE FOR CALIFORNIA

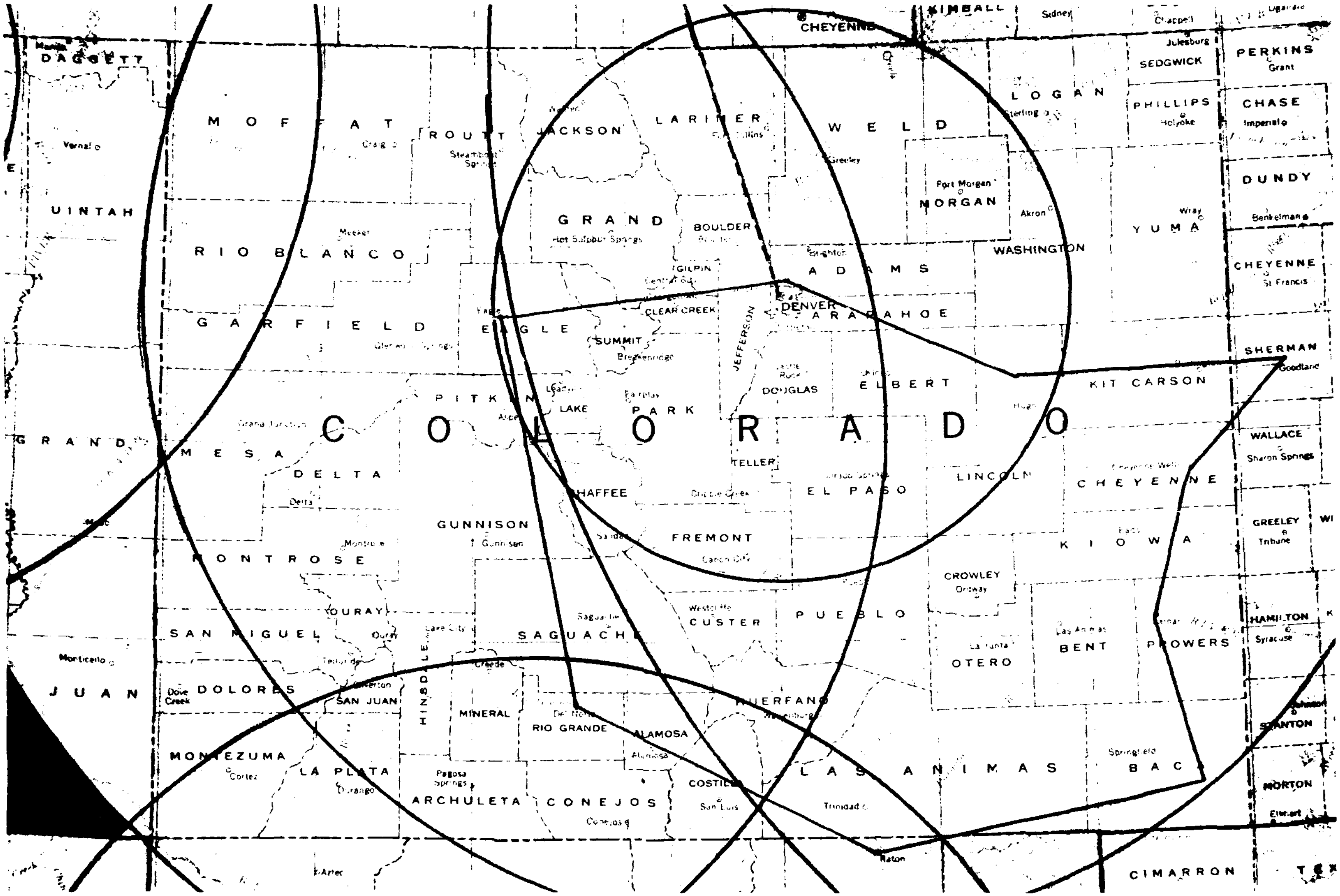


FIGURE A-70 CROSS COUNTRY OPERATING AREA COVERAGE FOR COLORADO

FIGURE A-71 CROSS COUNTRY OPERATING AREA COVERAGE FOR CONNECTICUT

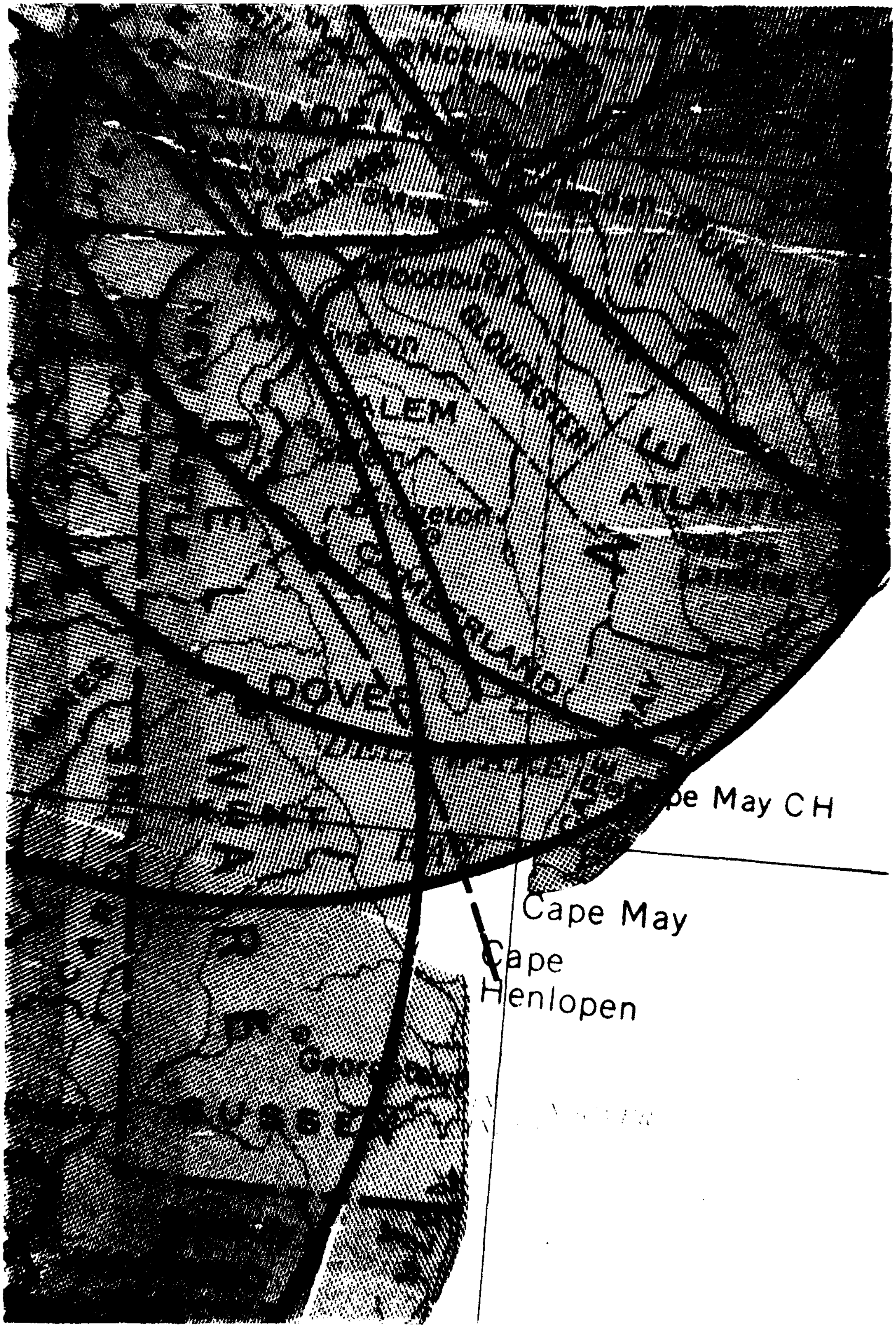


FIGURE A-72 CROSS COUNTRY OPERATING AREA COVERAGE FOR DELAWARE

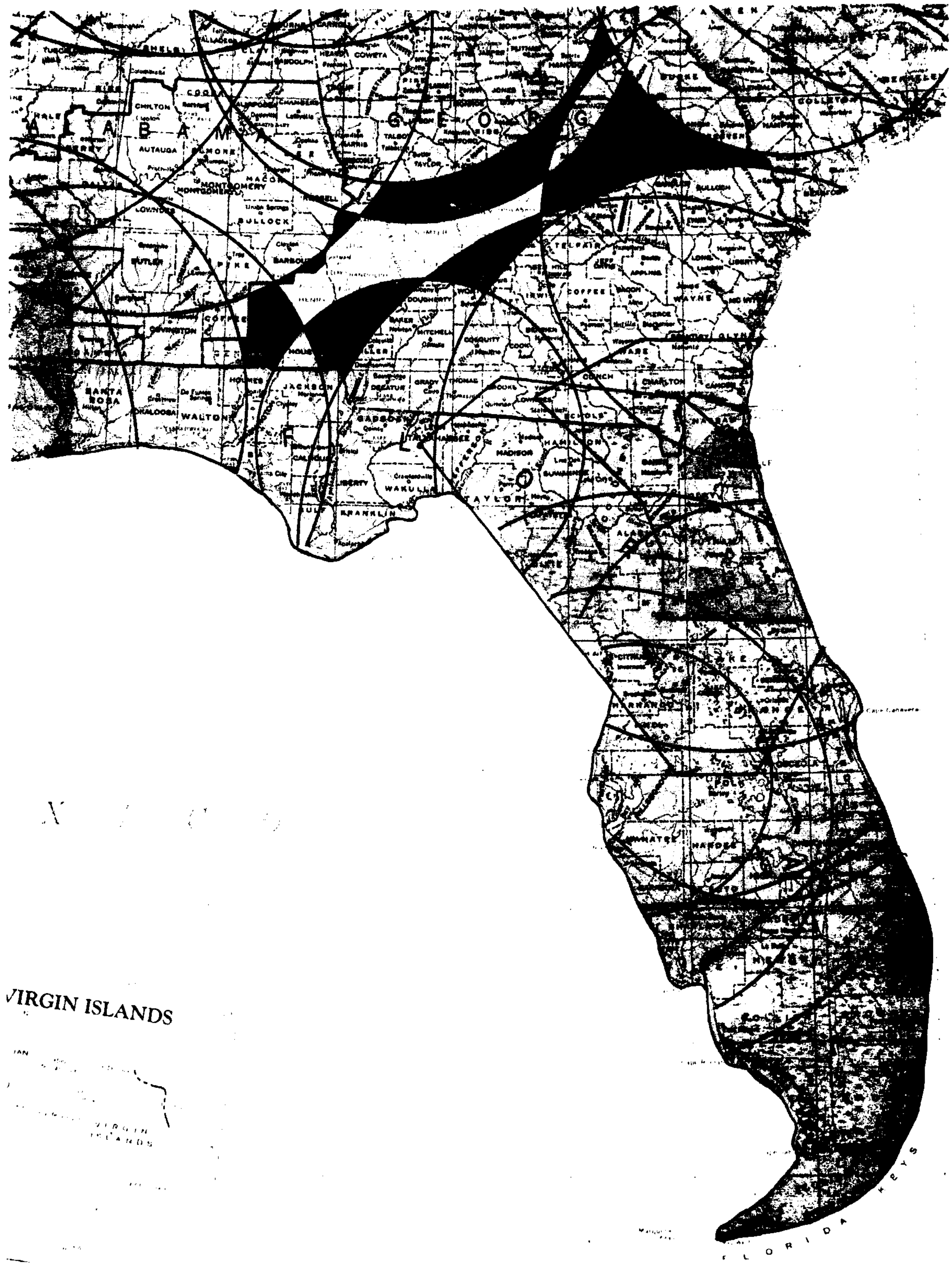


FIGURE A-73 CROSS COUNTRY OPERATING AREA COVERAGE FOR FLORIDA

FIGURE A-74 CROSS COUNTRY OPERATING AREA COVERAGE FOR GEORGIA

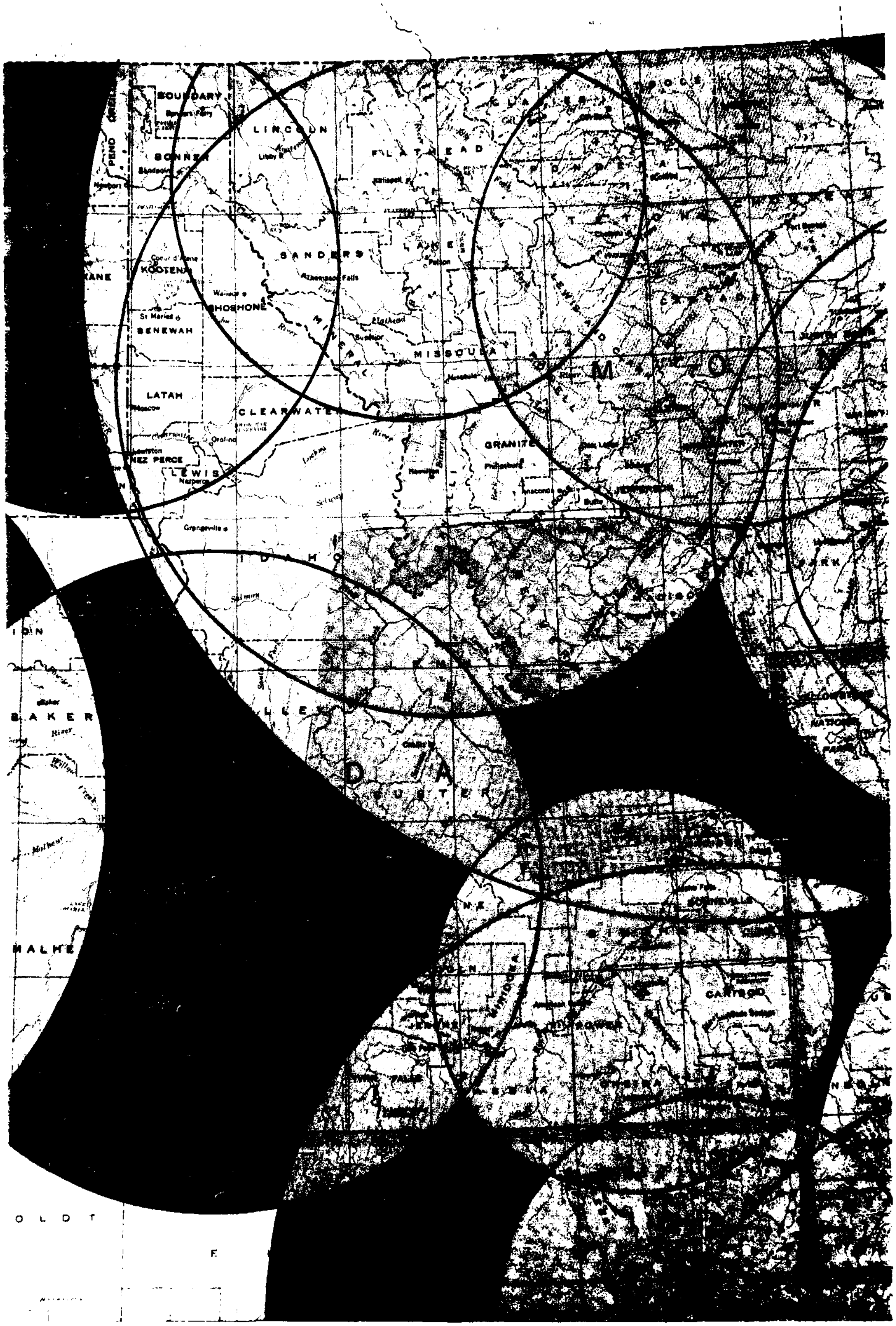


FIGURE A-75 CROSS COUNTRY OPERATING AREA COVERAGE FOR IDAHO

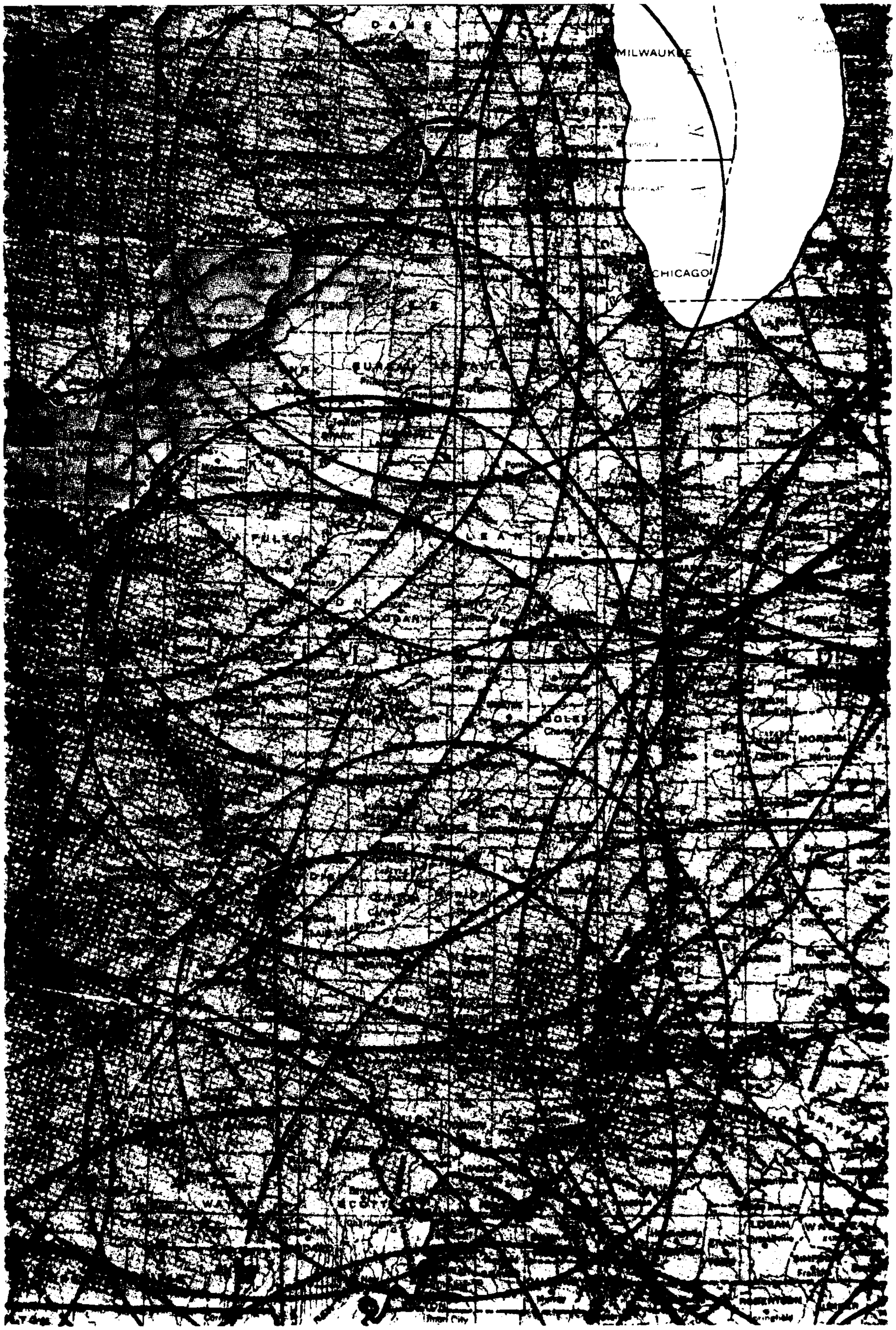


FIGURE A-76 CROSS COUNTRY OPERATING AREA COVERAGE FOR ILLINOIS

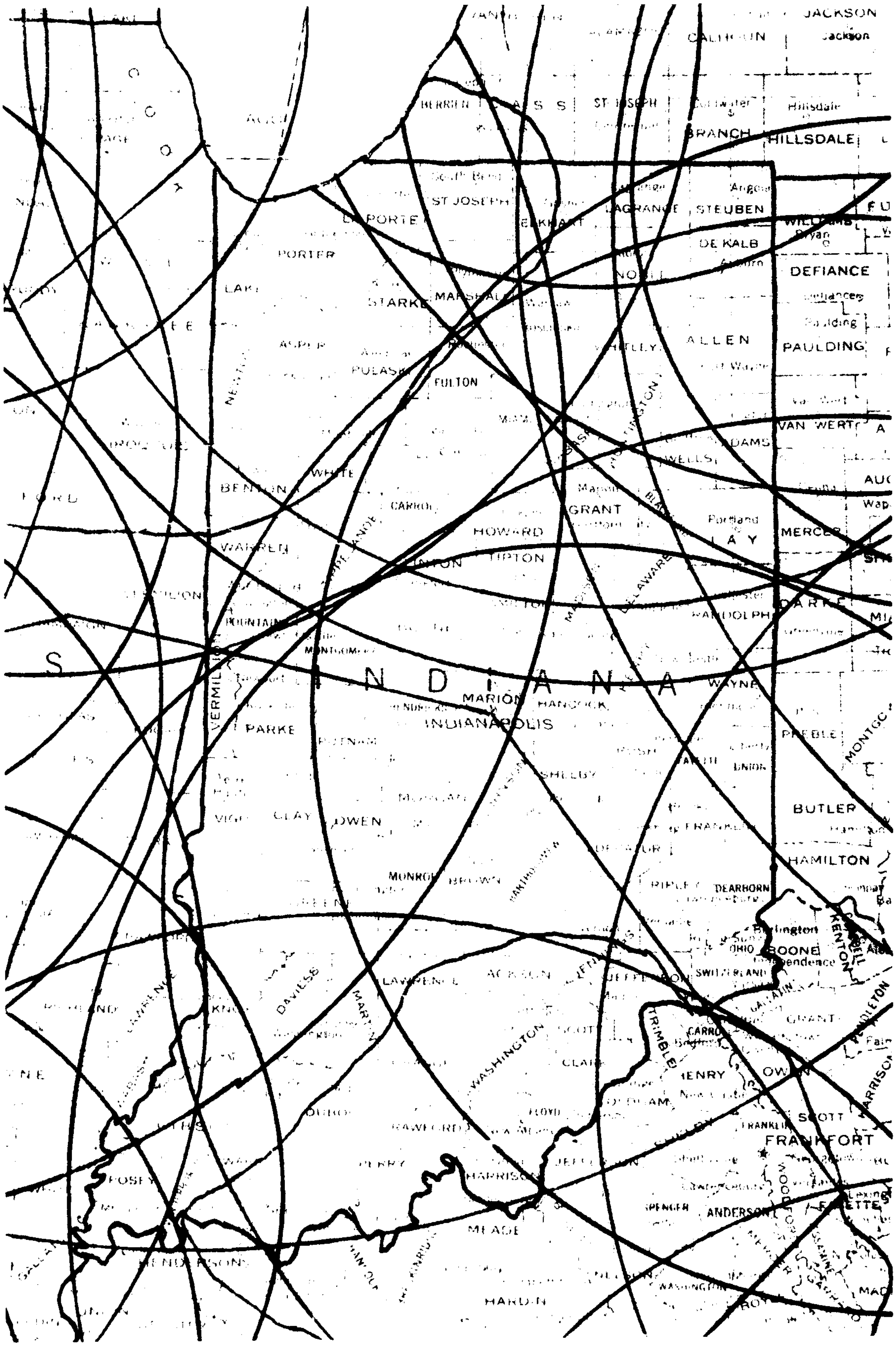


FIGURE A-77 CROSS COUNTRY OPERATING AREA COVERAGE FOR INDIANA

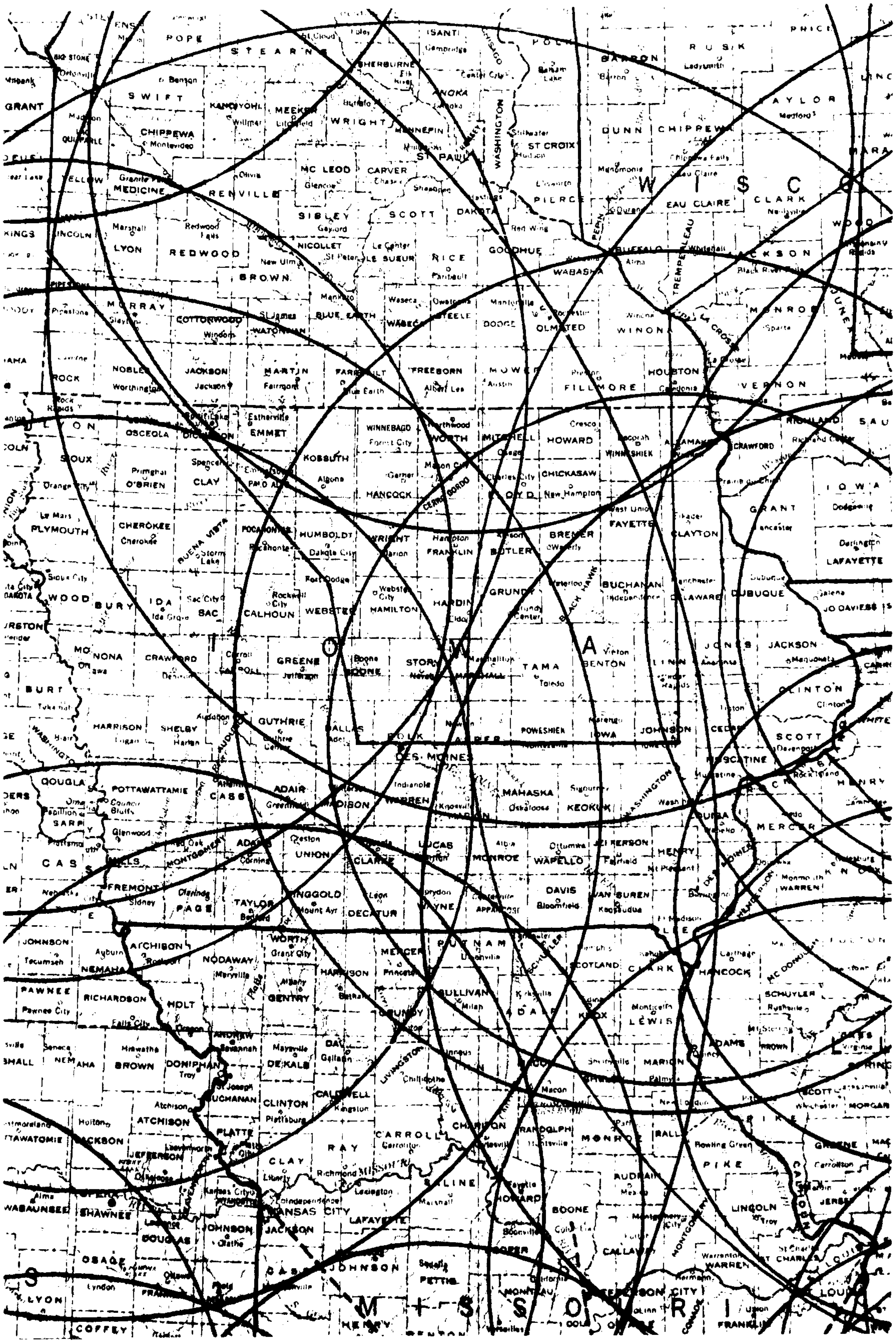


FIGURE A-78 CROSS COUNTRY OPERATING AREA COVERAGE FOR IOWA

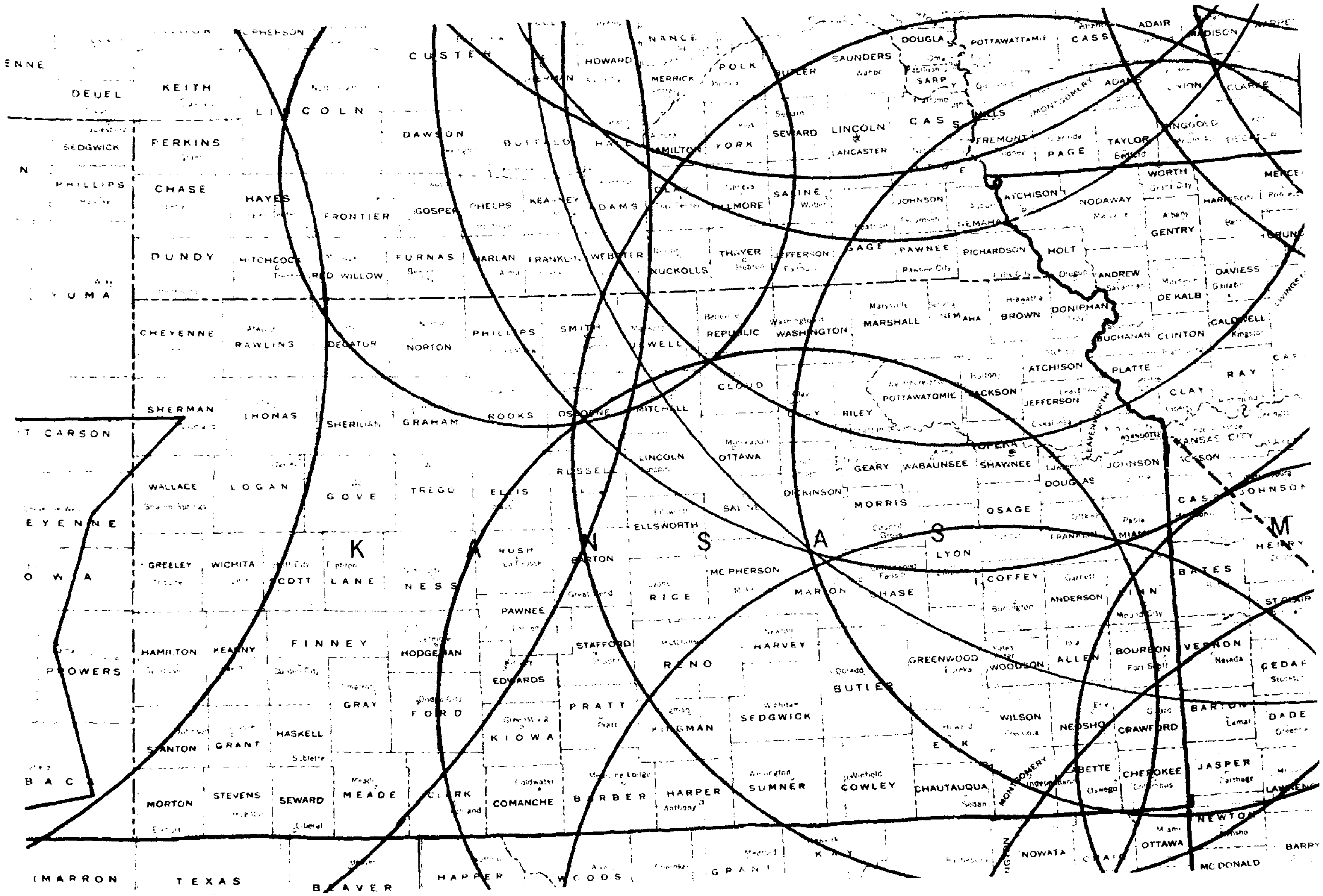


FIGURE A-79 CROSS COUNTRY OPERATING AREA COVERAGE FOR KANSAS

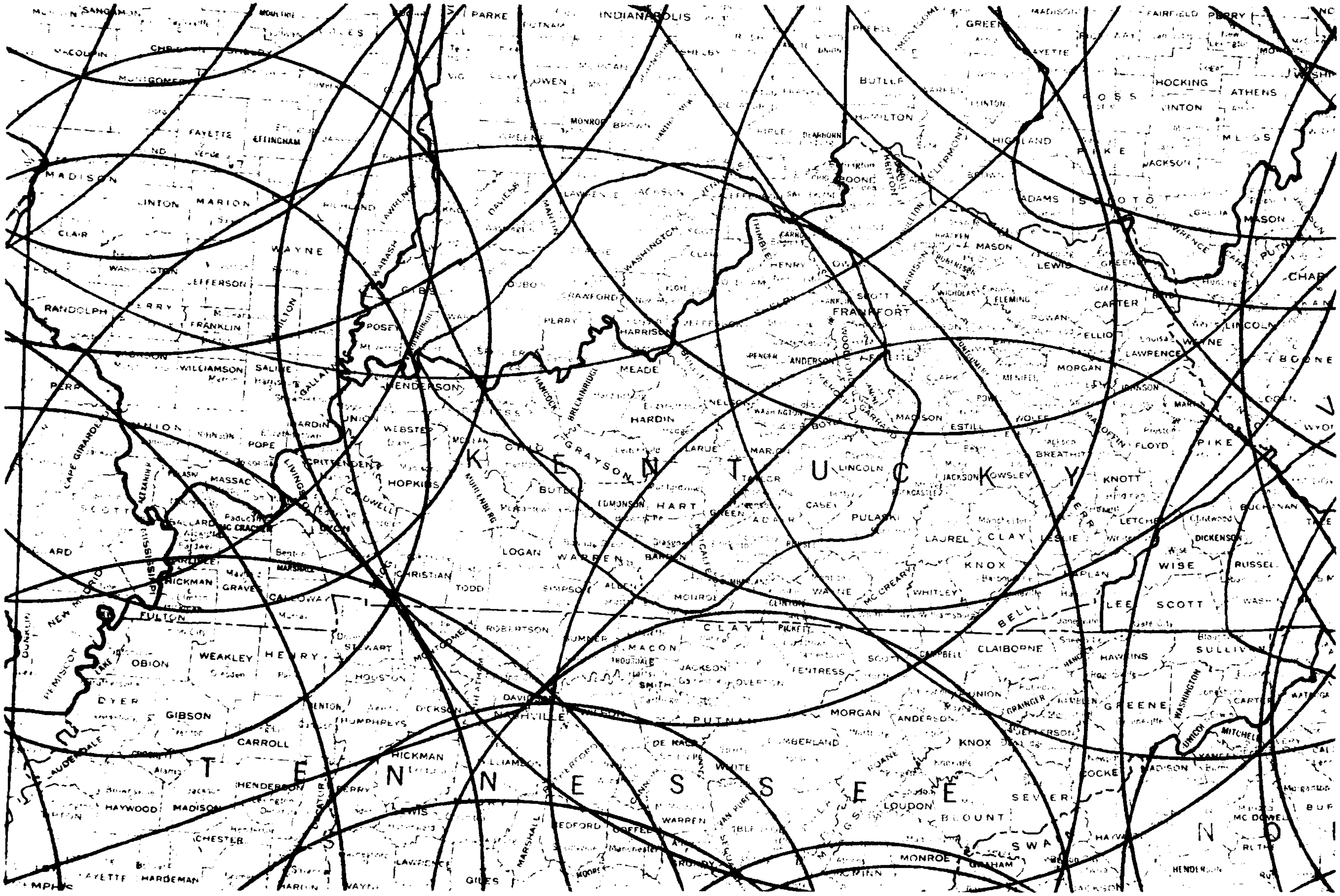


FIGURE A-80 CROSS COUNTRY OPERATING AREA COVERAGE FOR KENTUCKY

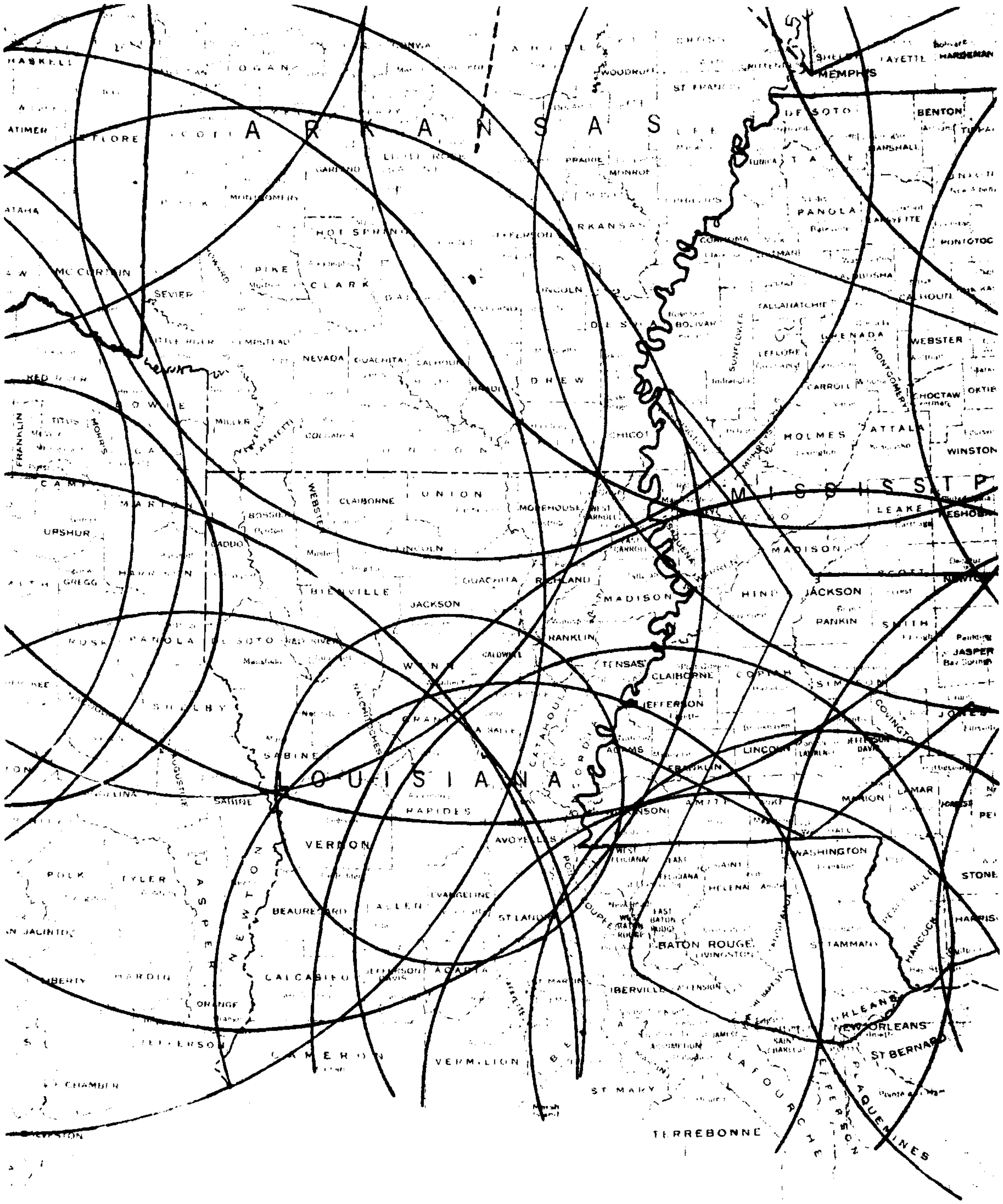


FIGURE A-81 CROSS COUNTRY OPERATING AREA COVERAGE FOR LOUISIANA

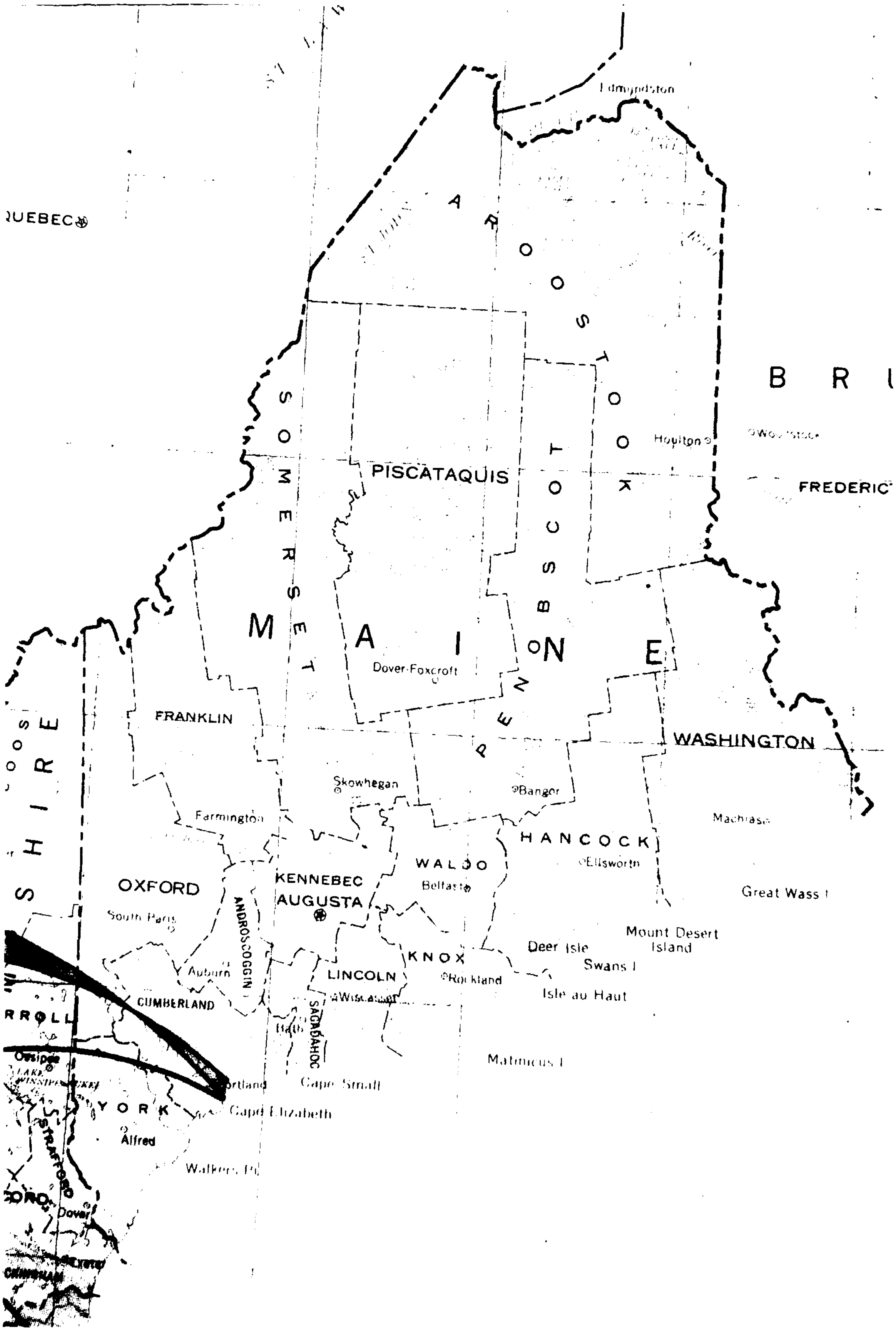


FIGURE A-82 CROSS COUNTRY OPERATING AREA COVERAGE FOR MAINE

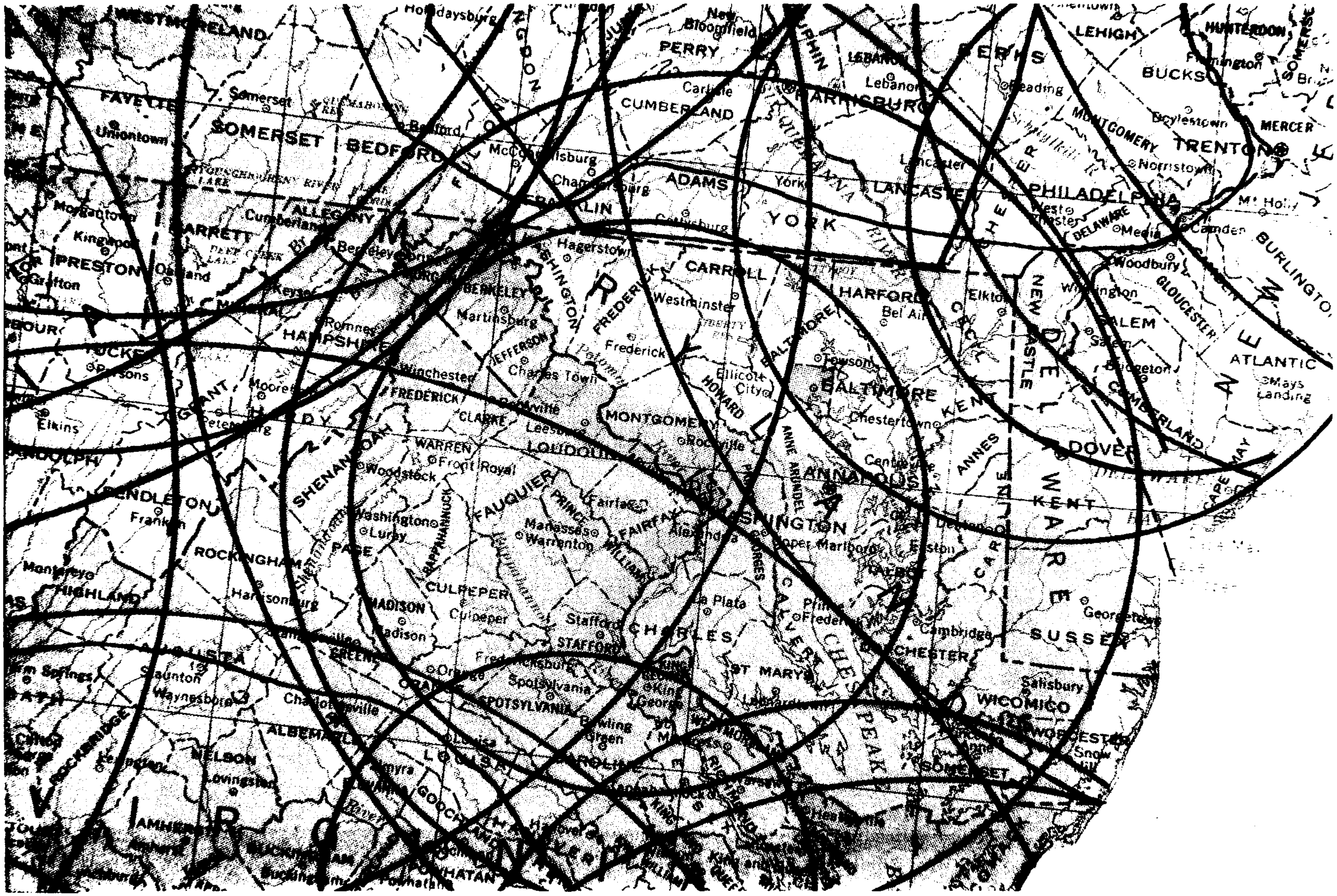


FIGURE A-83 CROSS COUNTRY OPERATING AREA COVERAGE FOR MARYLAND

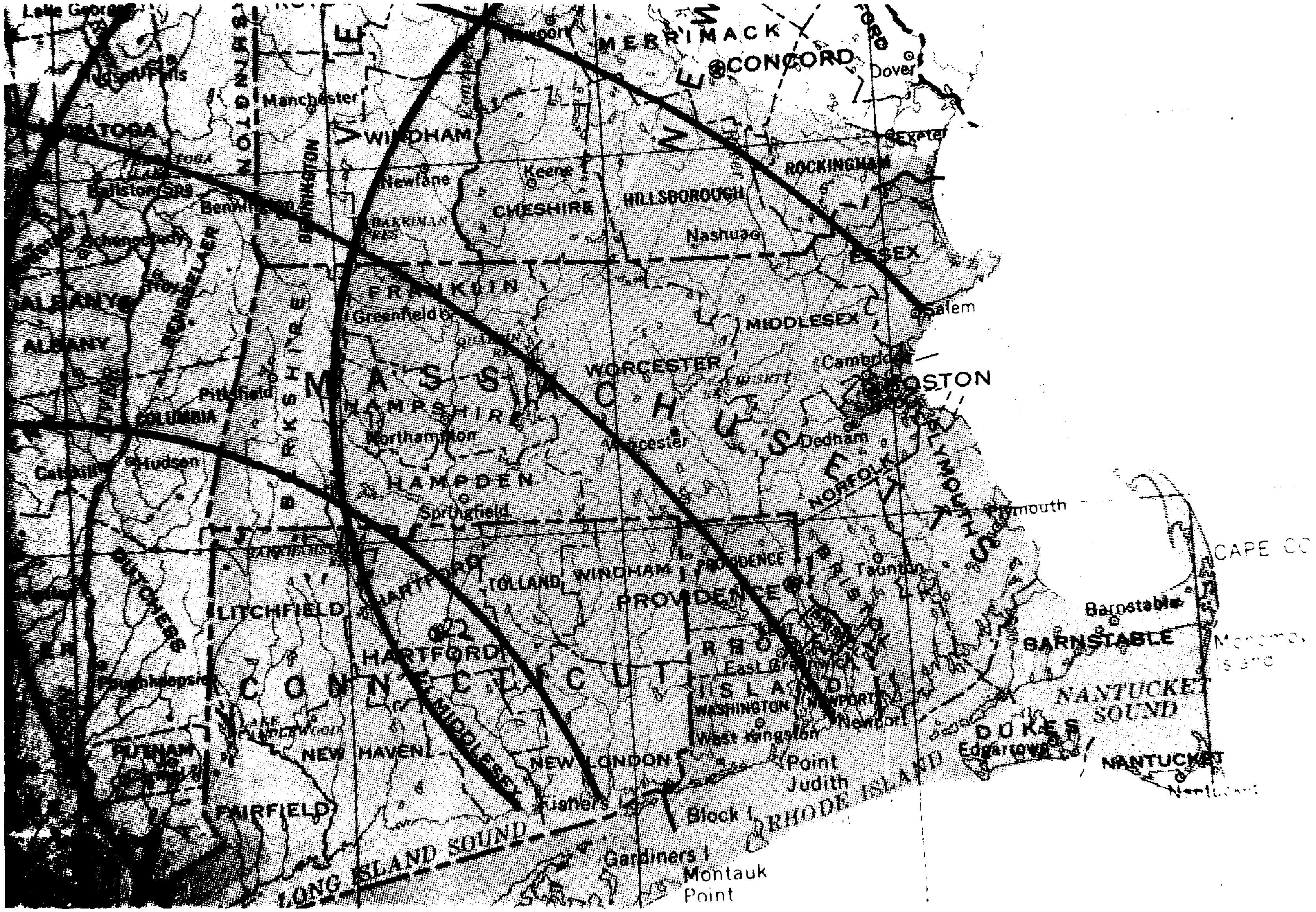


FIGURE A-84 CROSS COUNTRY OPERATING AREA COVERAGE FOR MASSACHUSETTS

FIGURE A-85 CROSS COUNTRY OPERATING AREA COVERAGE FOR MICHIGAN

FIGURE A-86 CROSS COUNTRY OPERATING AREA COVERAGE FOR MINNESOTA

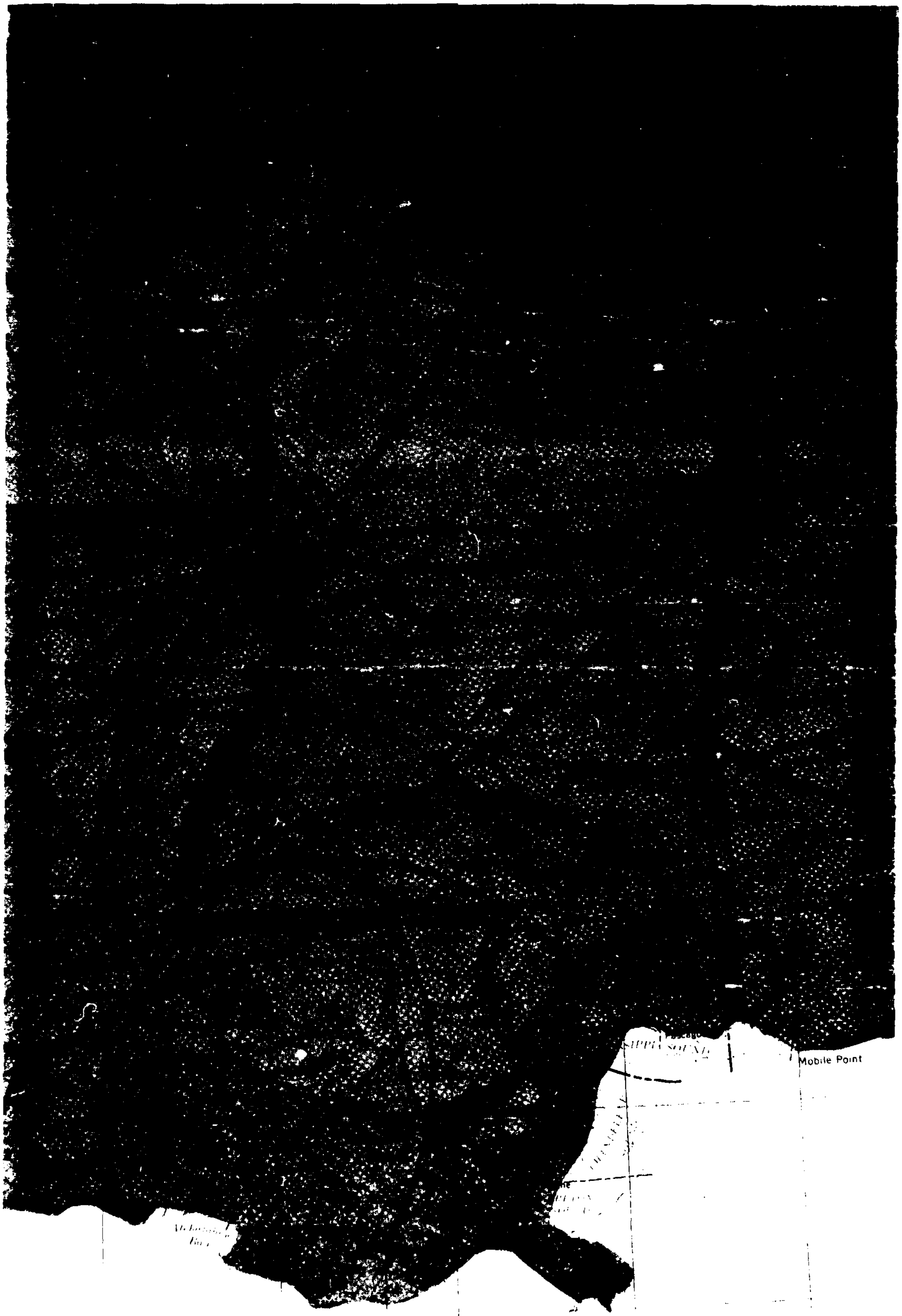


FIGURE A-87 CROSS COUNTRY OPERATING AREA COVERAGE FOR MISSISSIPPI

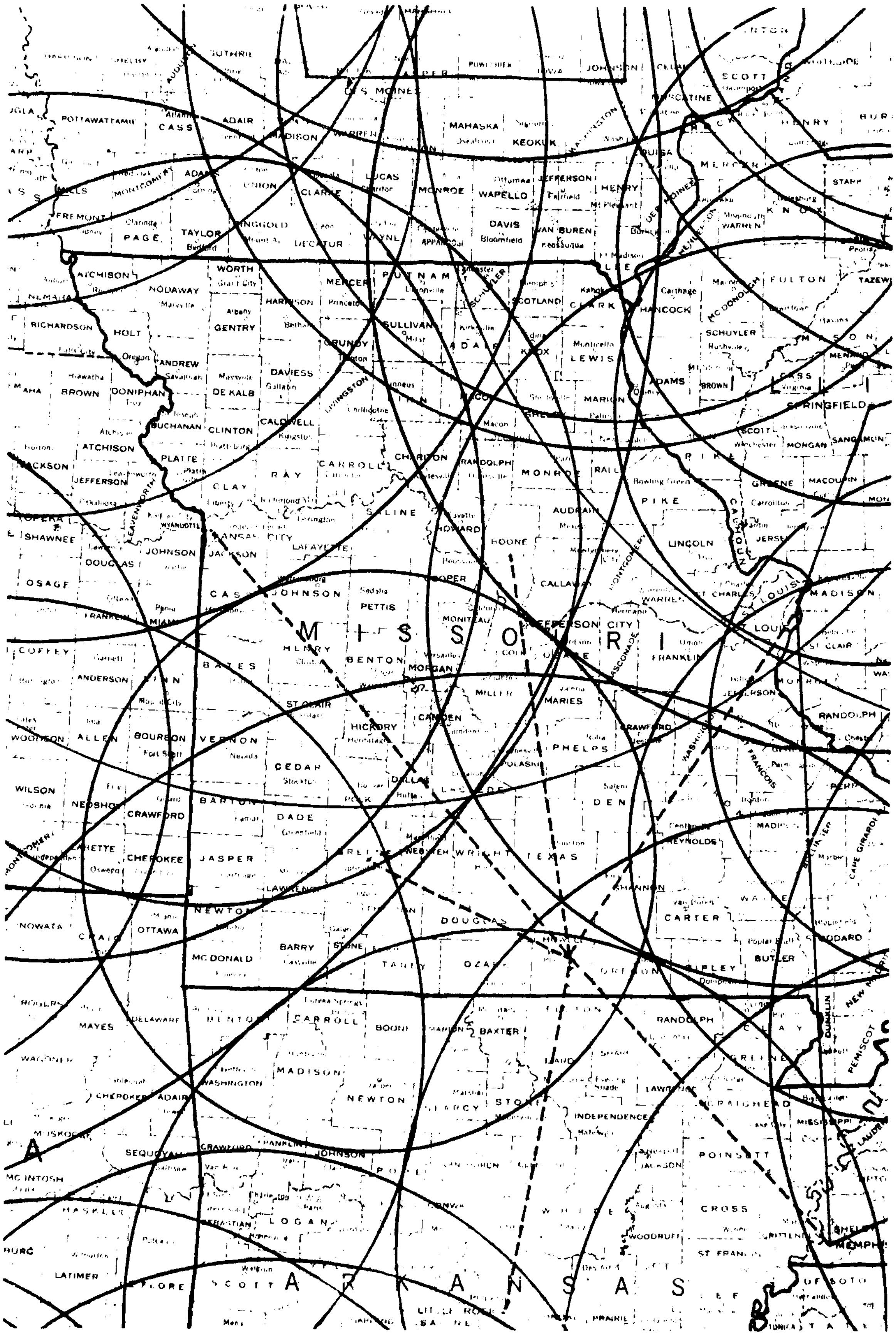


FIGURE A-88 CROSS COUNTRY OPERATING AREA COVERAGE FOR MISSOURI

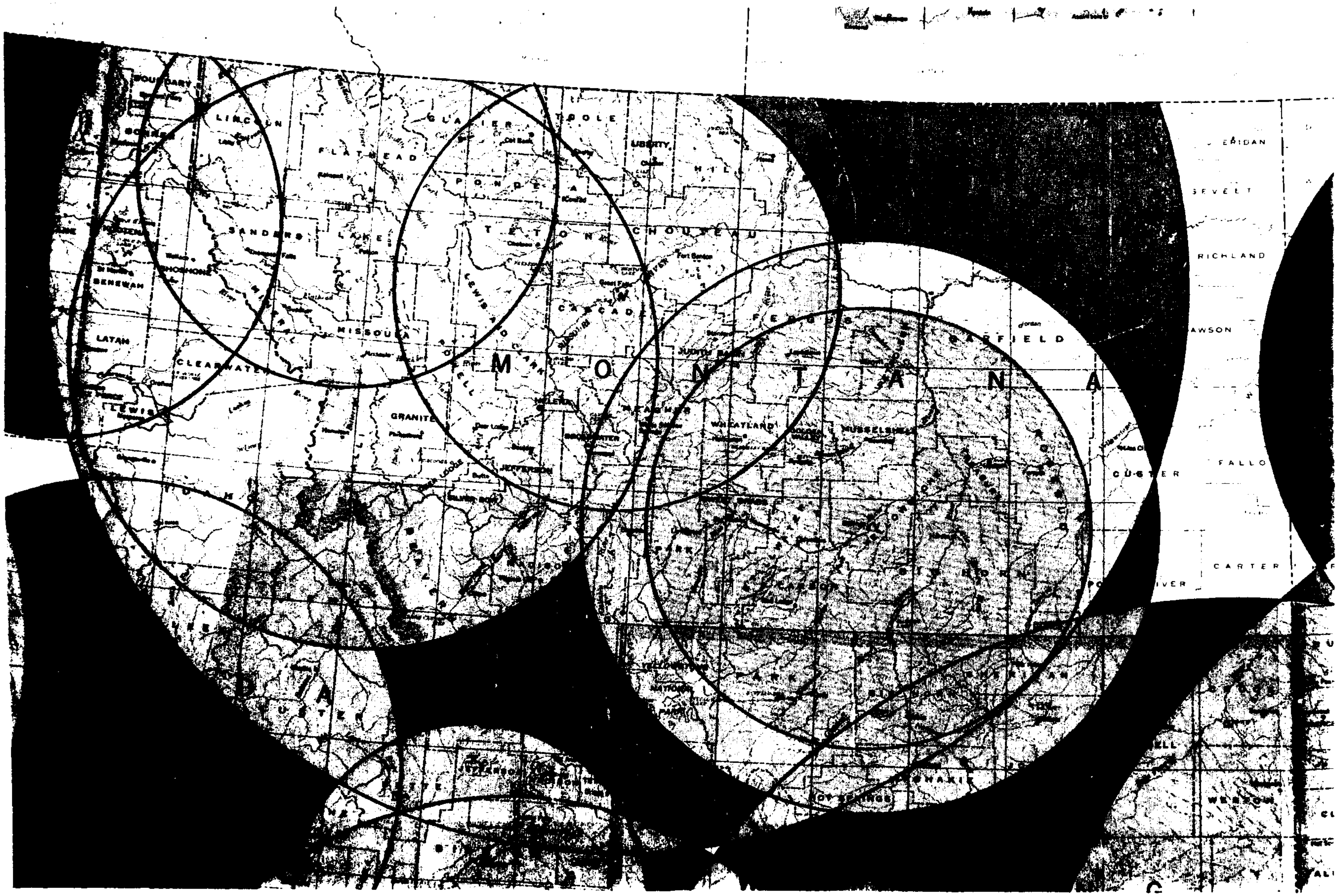


FIGURE A-89 CROSS COUNTRY OPERATING AREA COVERAGE FOR MONTANA

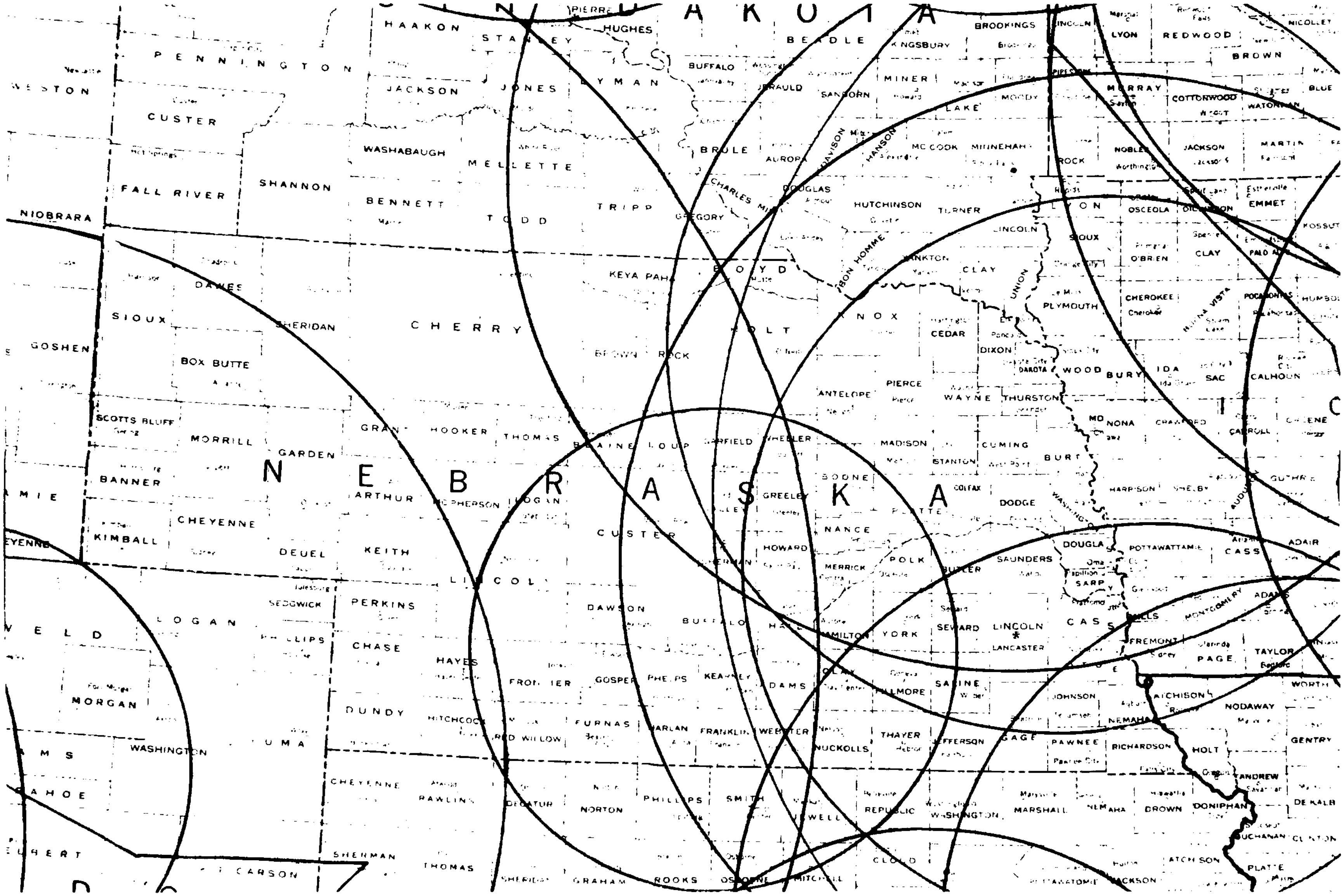


FIGURE A-90 CROSS COUNTRY OPERATING AREA COVERAGE FOR NEBRASKA

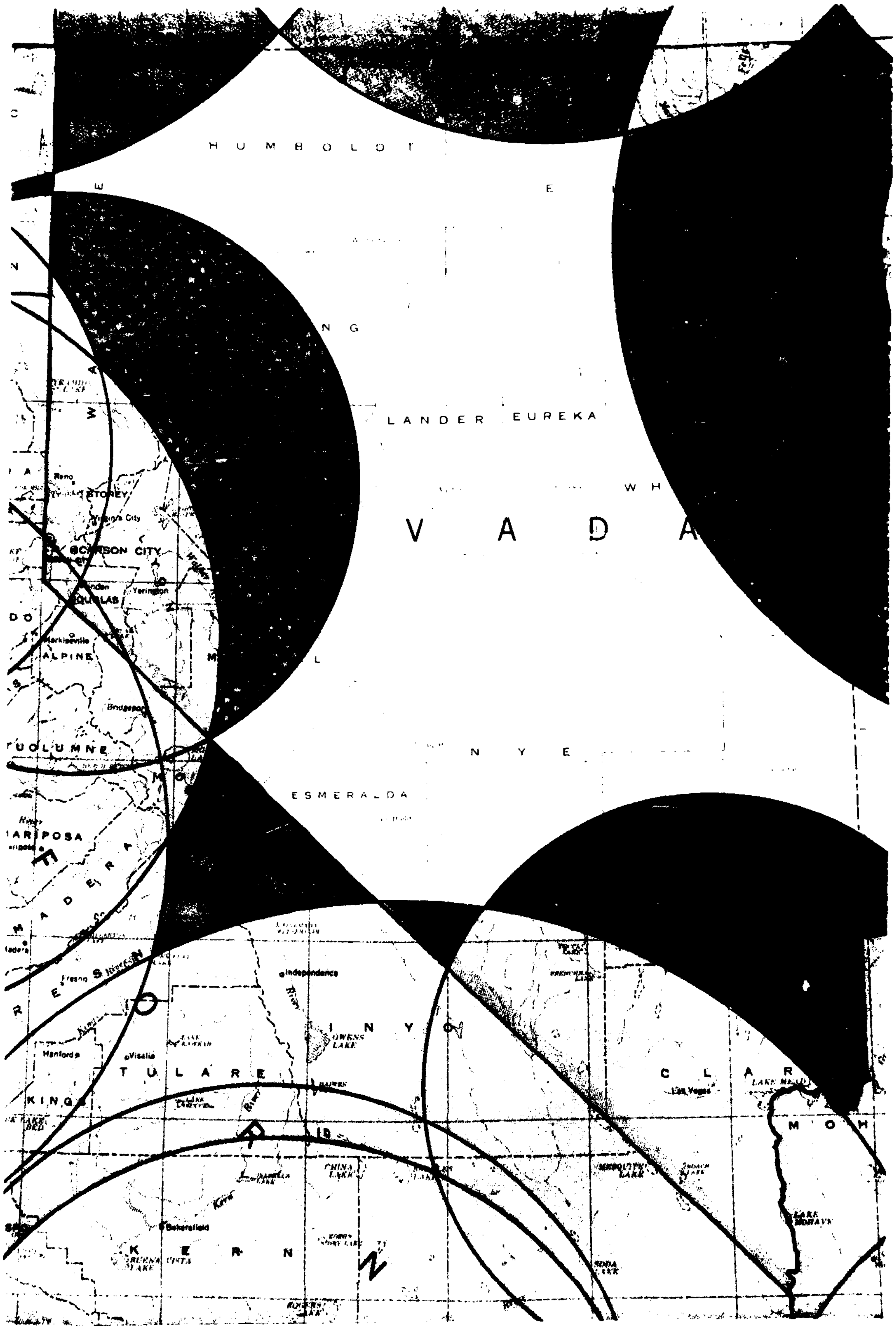


FIGURE A-91 CROSS COUNTRY OPERATING AREA COVERAGE FOR NEVADA

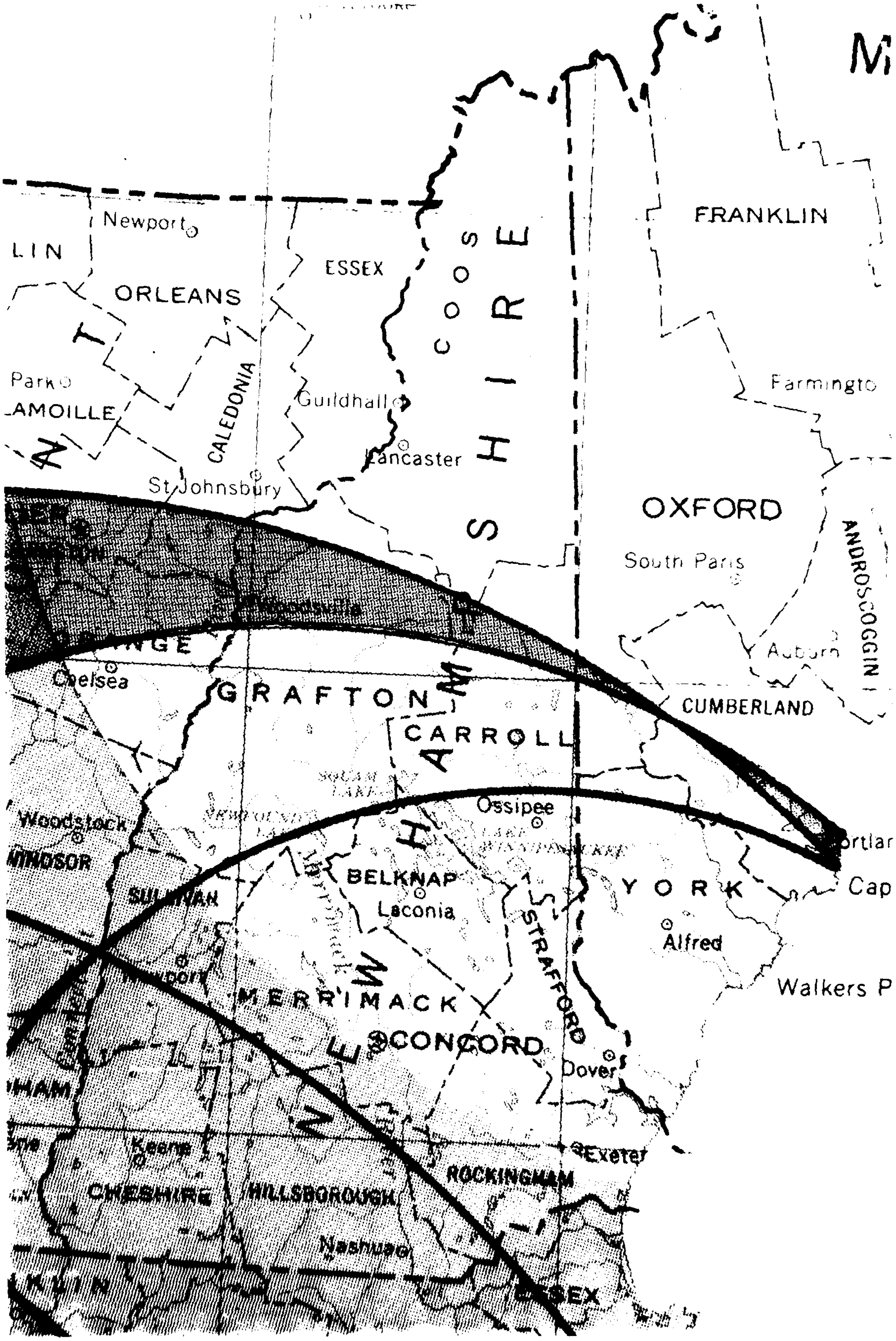


FIGURE A-92 CROSS COUNTRY OPERATING AREA COVERAGE FOR NEW HAMPSHIRE

FIGURE A-93 CROSS COUNTRY OPERATING AREA COVERAGE FOR NEW JERSEY

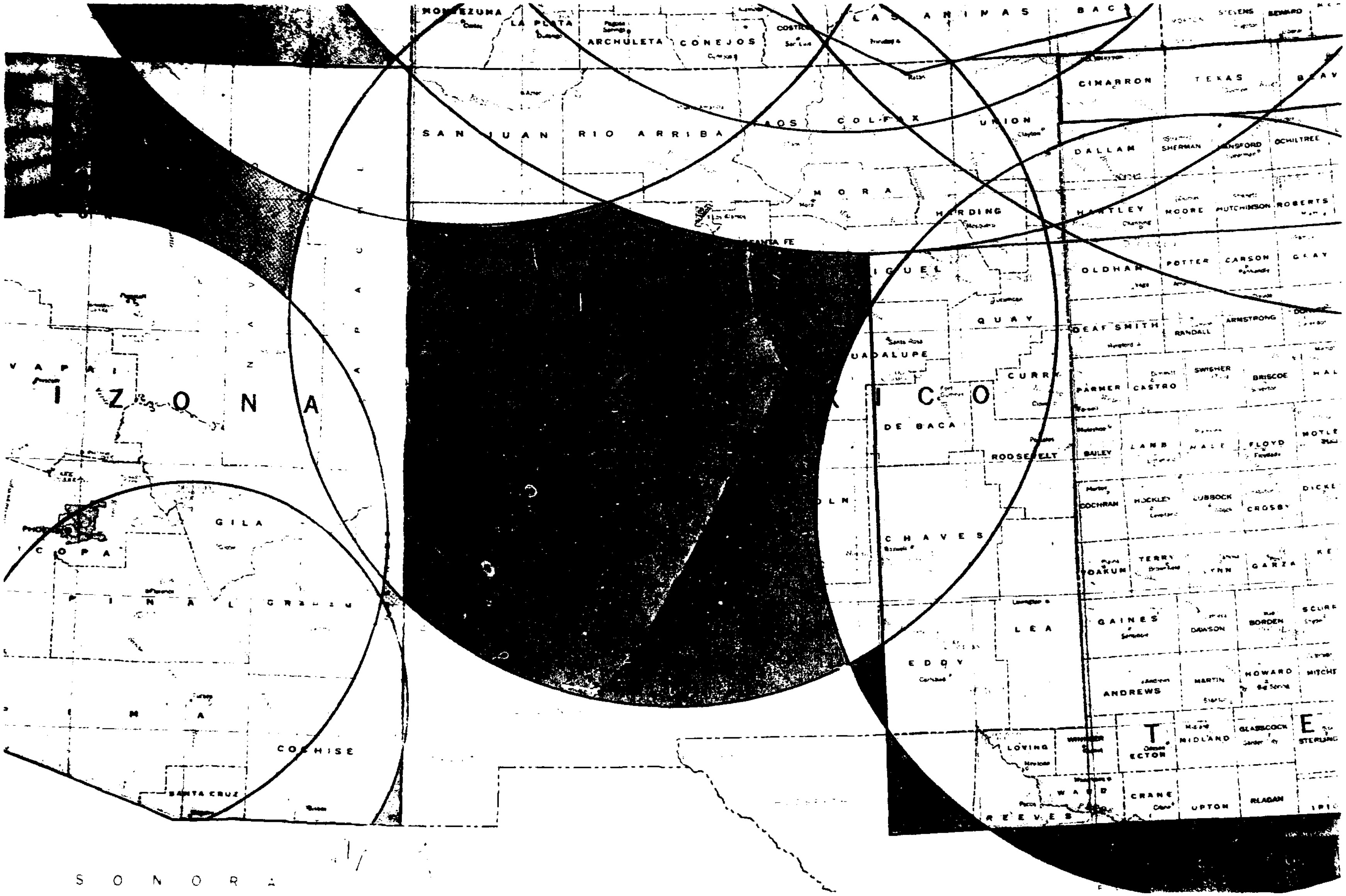


FIGURE A-94 CROSS COUNTRY OPERATING AREA COVERAGE FOR NEW MEXICO

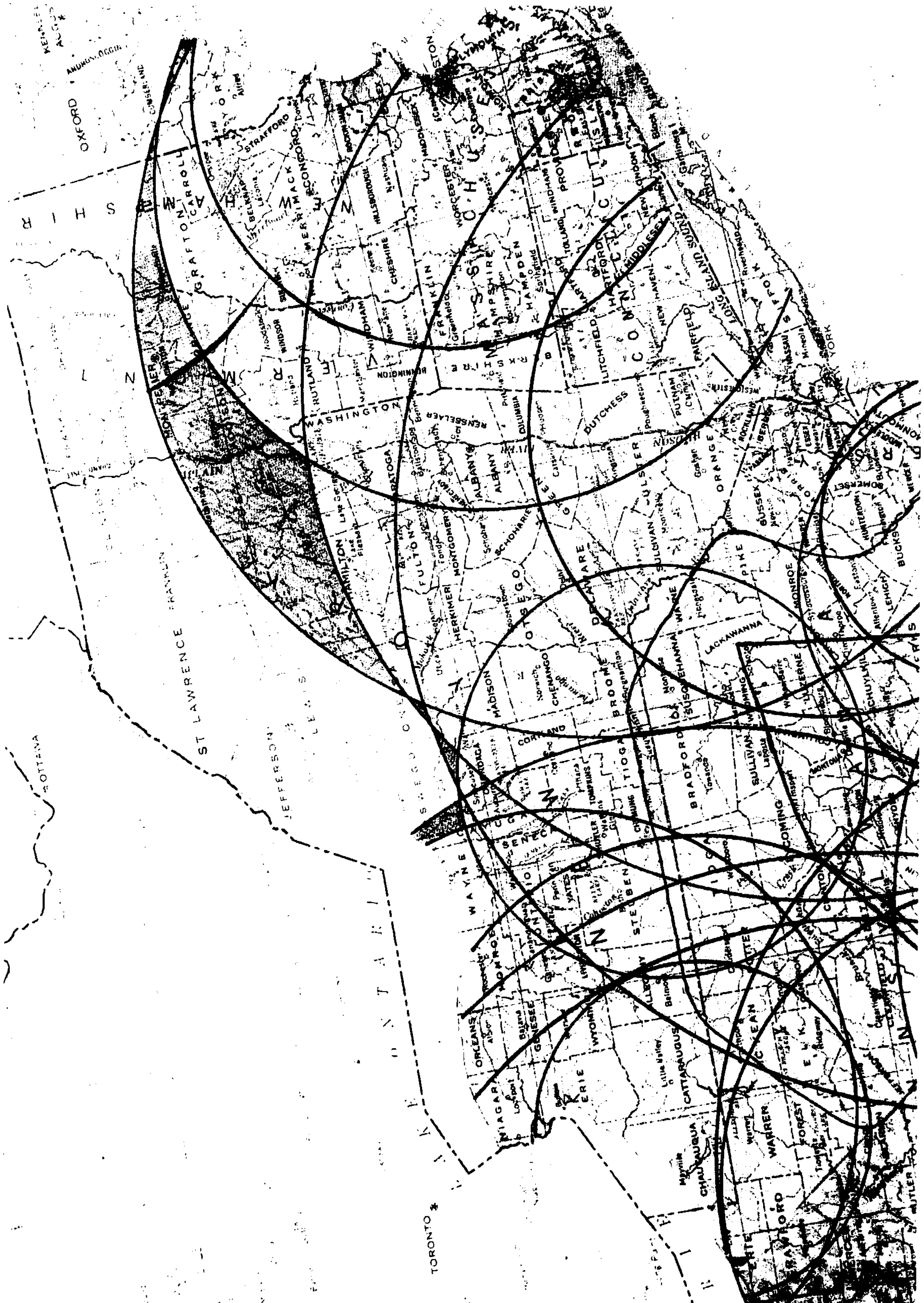


FIGURE A-95 CROSS COUNTRY OPERATING AREA COVERAGE FOR NEW YORK

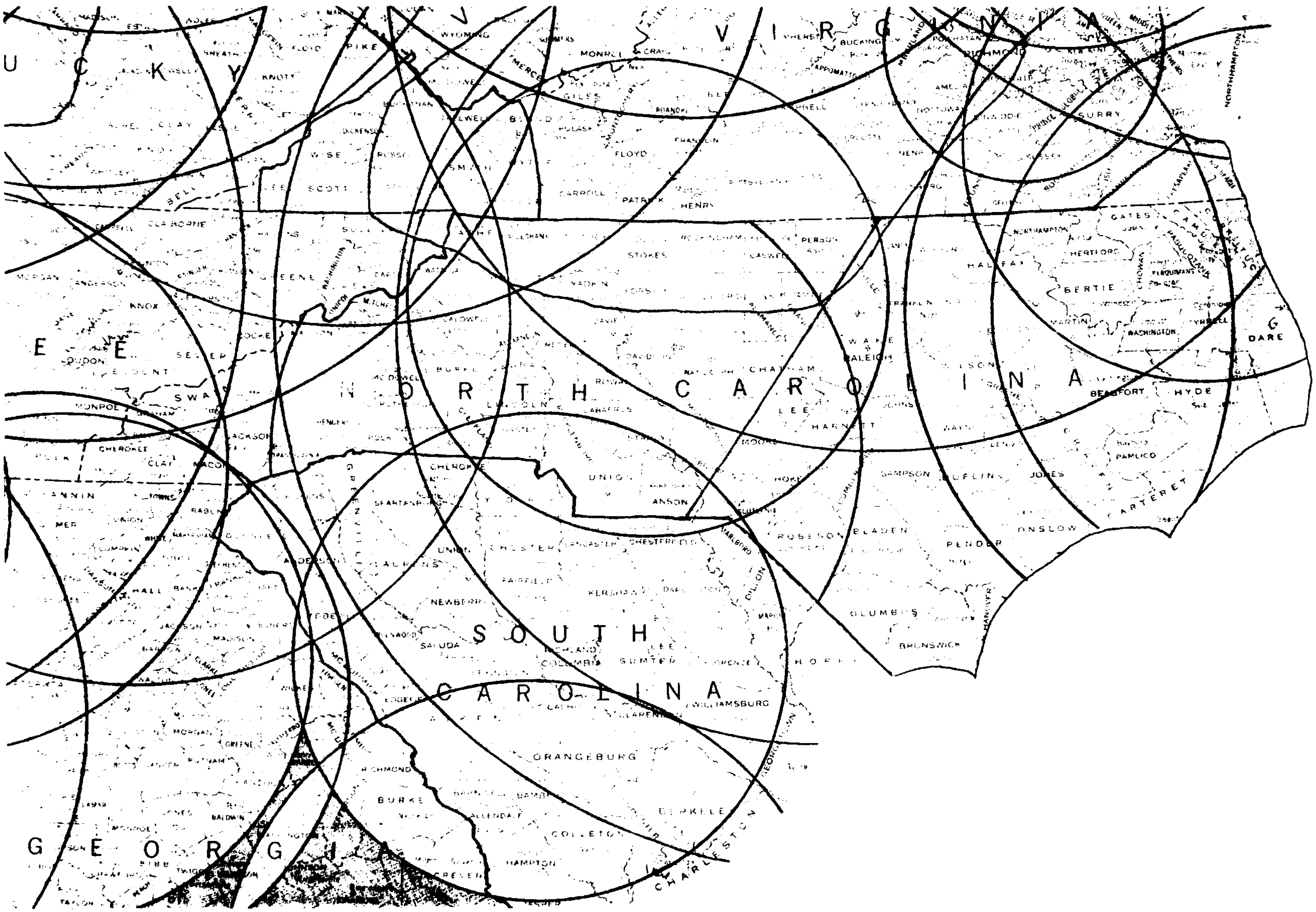


FIGURE A-96 CROSS COUNTRY OPERATING AREA COVERAGE FOR NORTH CAROLINA

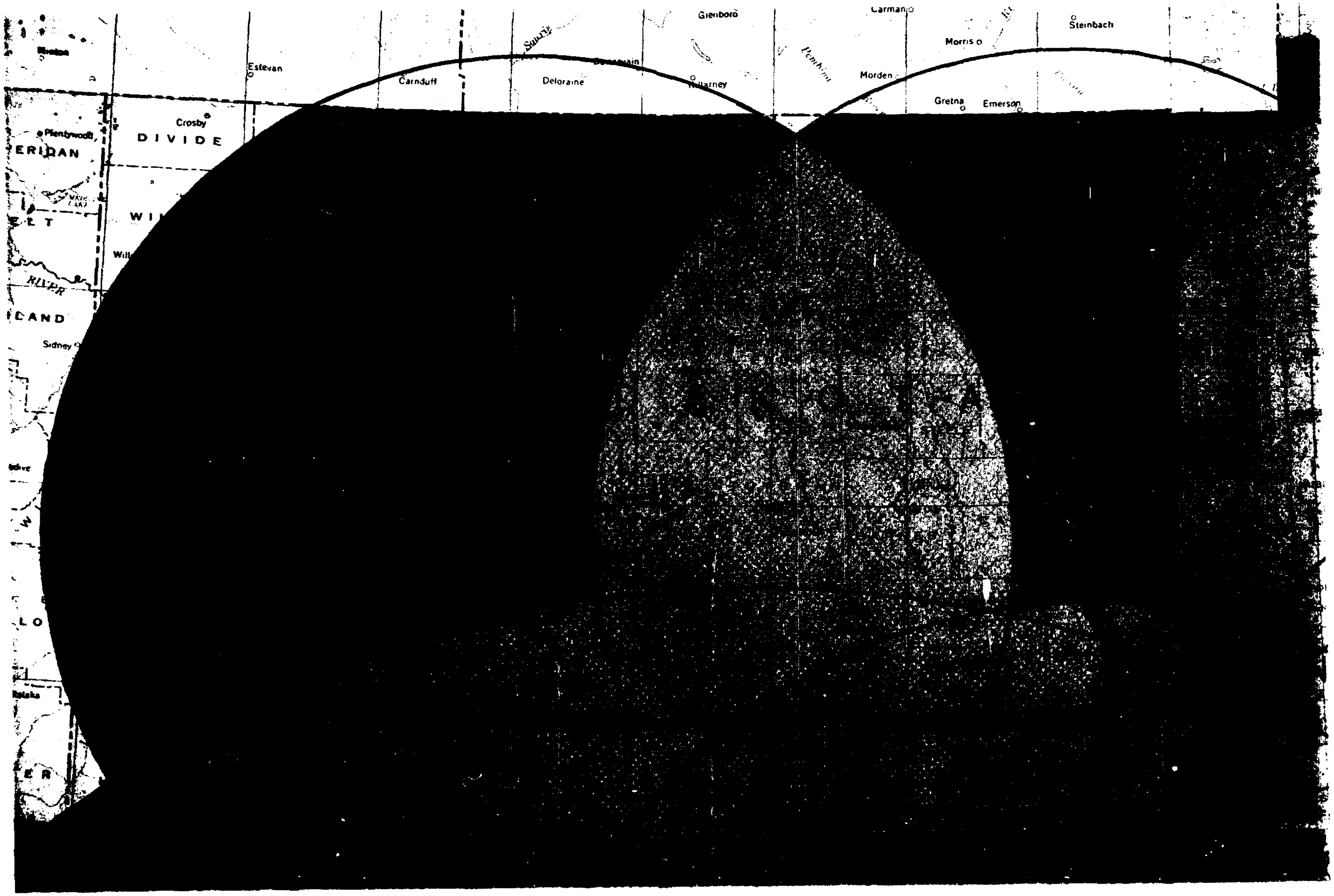


FIGURE A-97 CROSS COUNTRY OPERATING AREA COVERAGE FOR NORTH DAKOTA

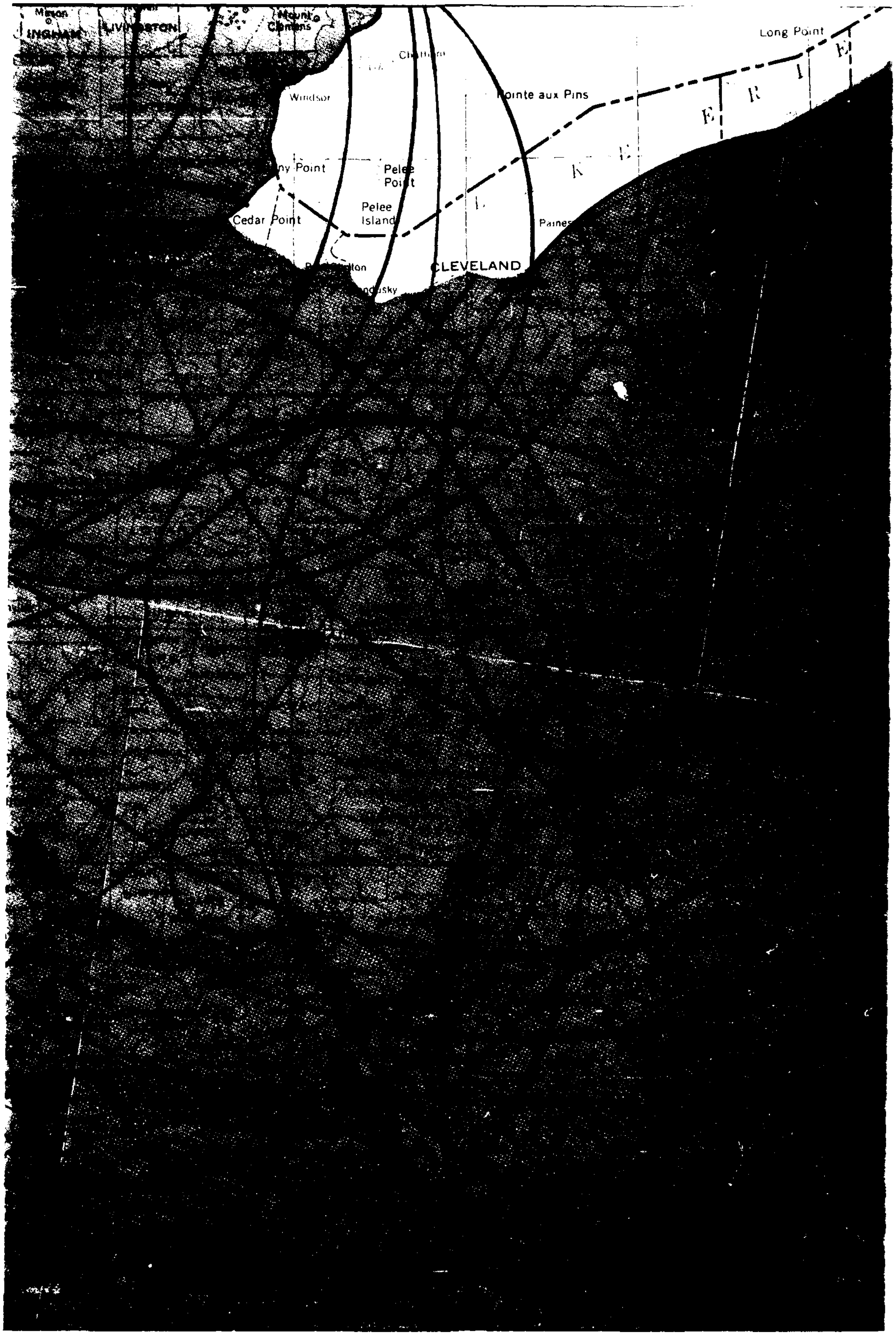


FIGURE A-98 CROSS COUNTRY OPERATING AREA COVERAGE FOR OHIO

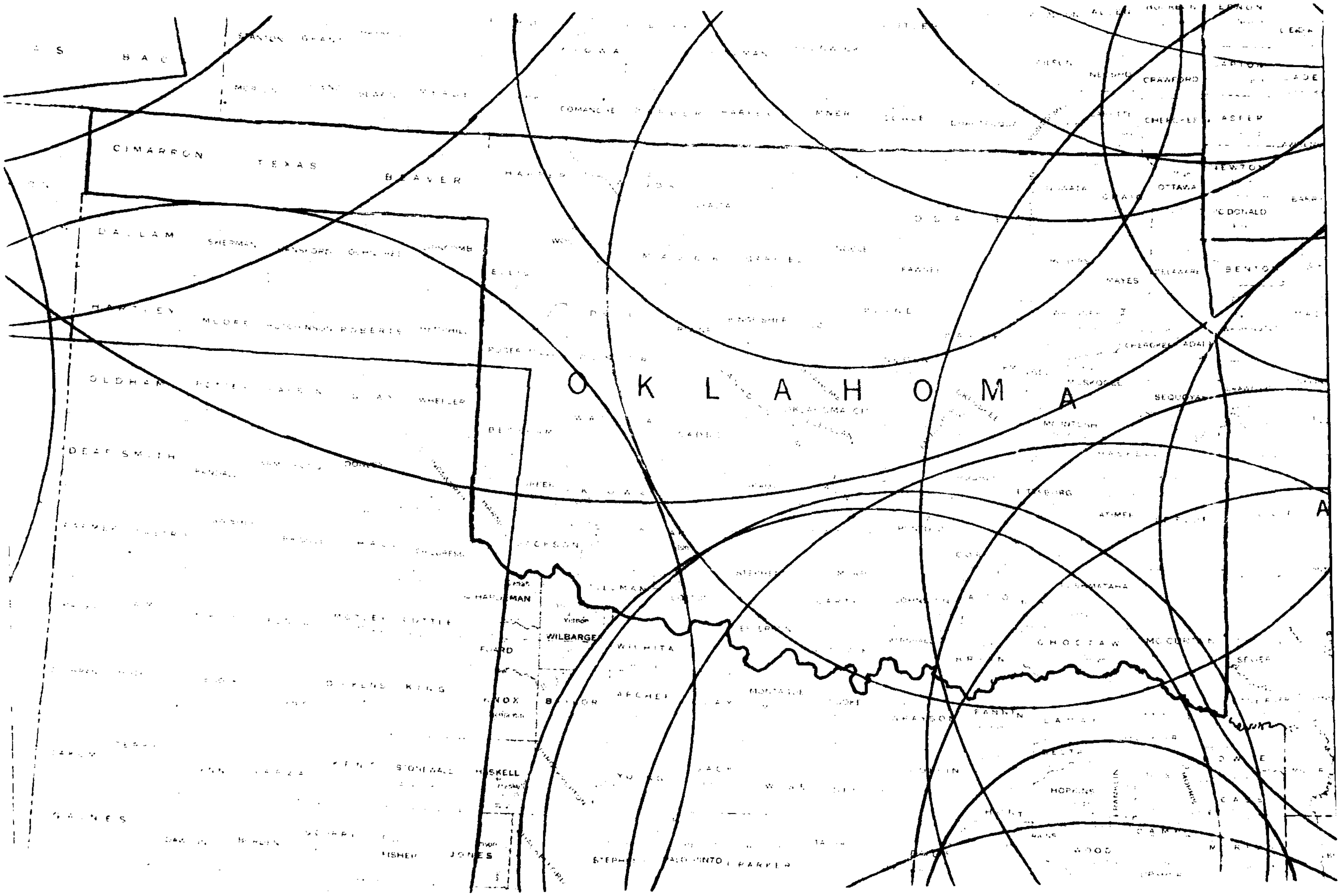


FIGURE A-99 CROSS COUNTRY OPERATING AREA COVERAGE FOR OKLAHOMA

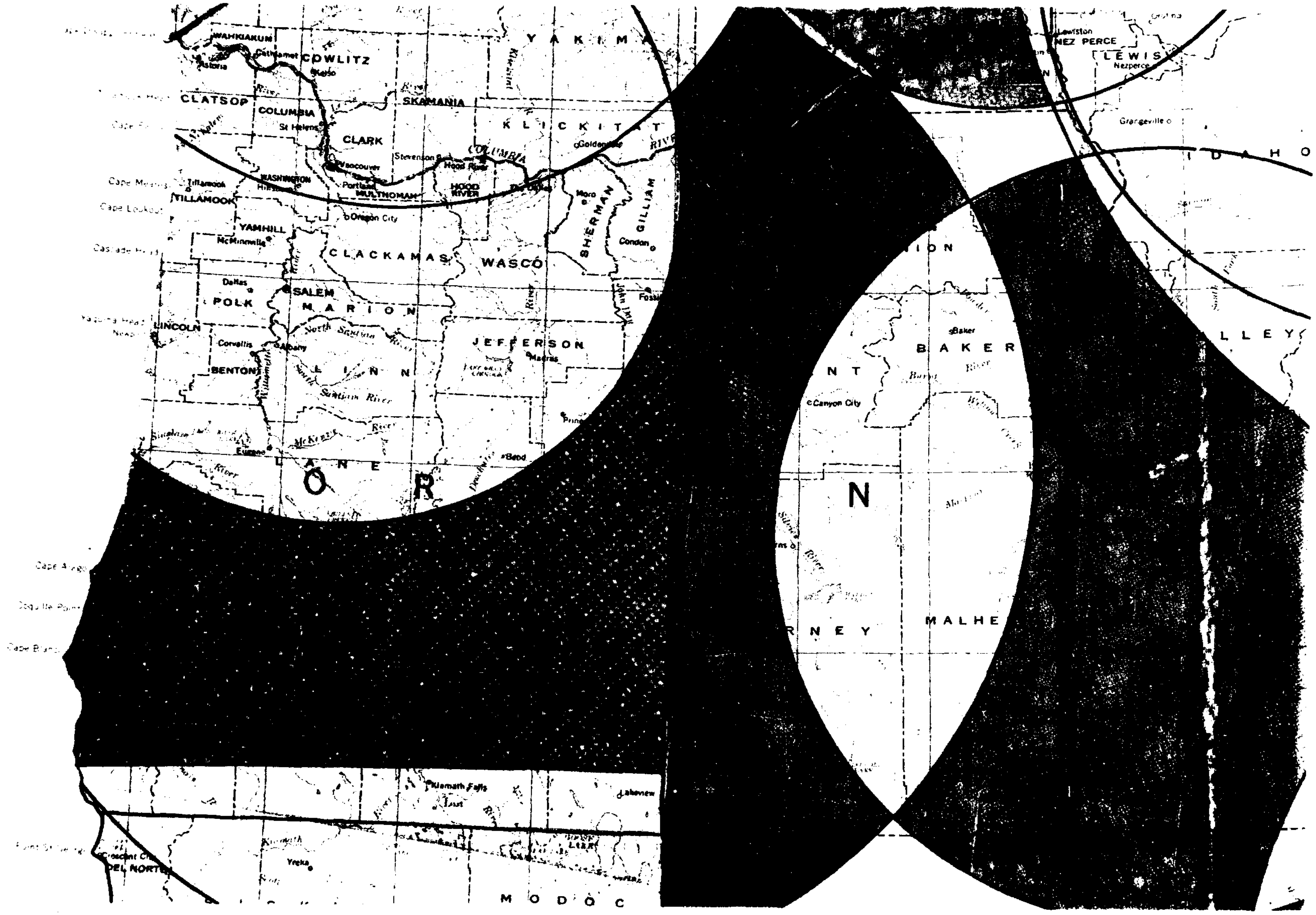


FIGURE A-100 CROSS COUNTRY OPERATING AREA COVERAGE FOR OREGON

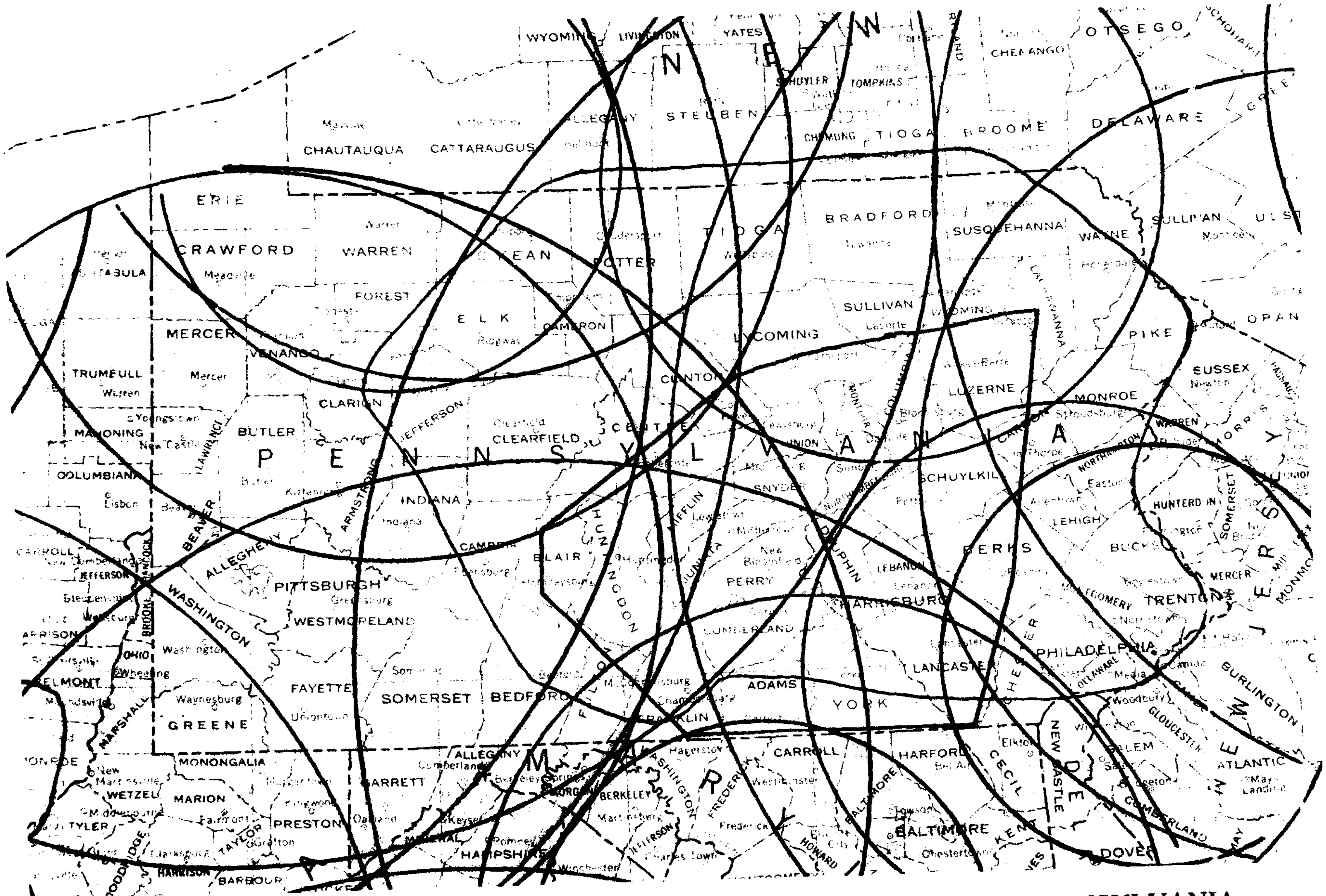


FIGURE A-101 CROSS COUNTRY OPERATING AREA COVERAGE FOR PENNSYLVANIA

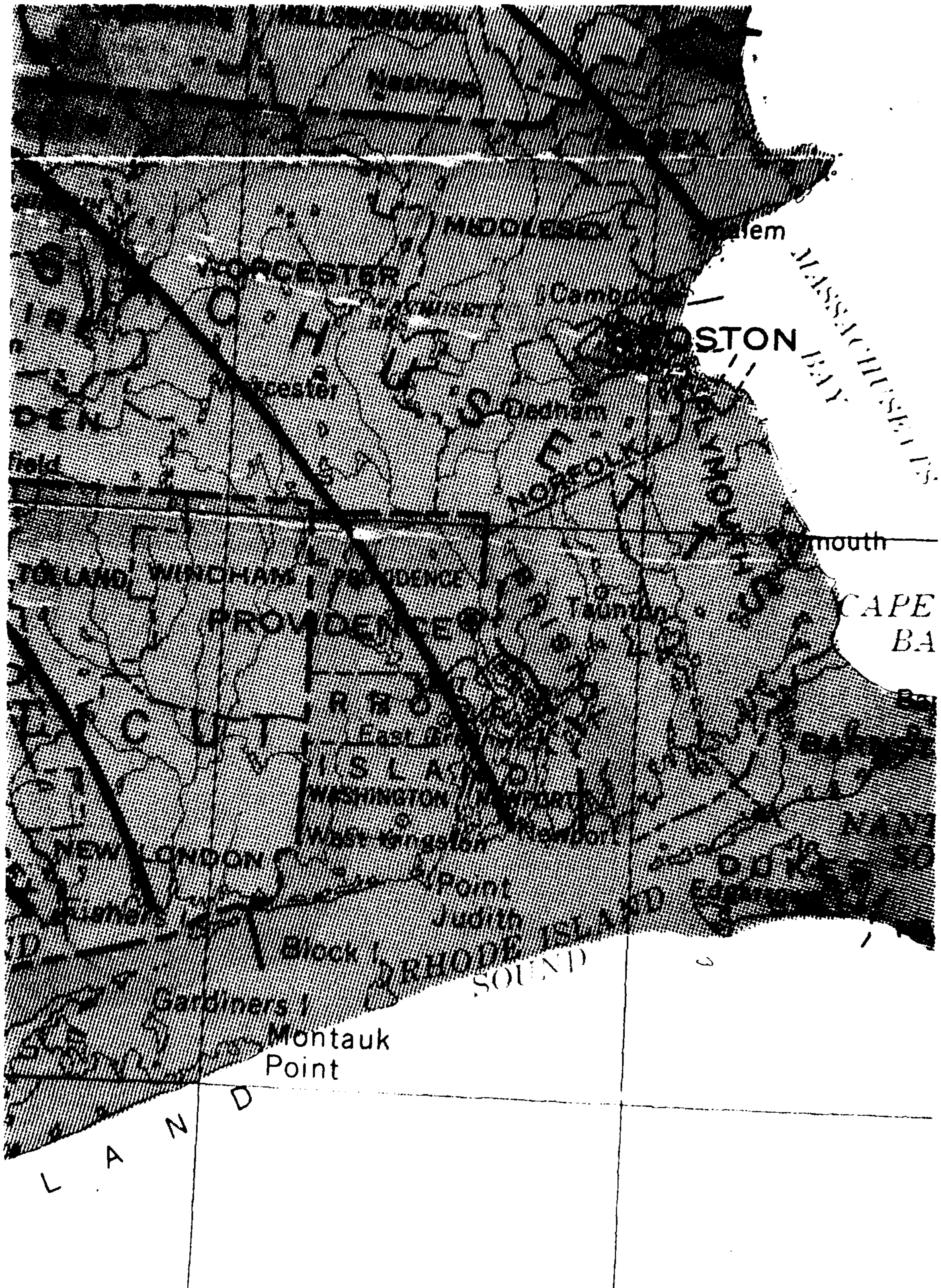


FIGURE A-102 CROSS COUNTRY OPERATING AREA COVERAGE FOR RHODE ISLAND

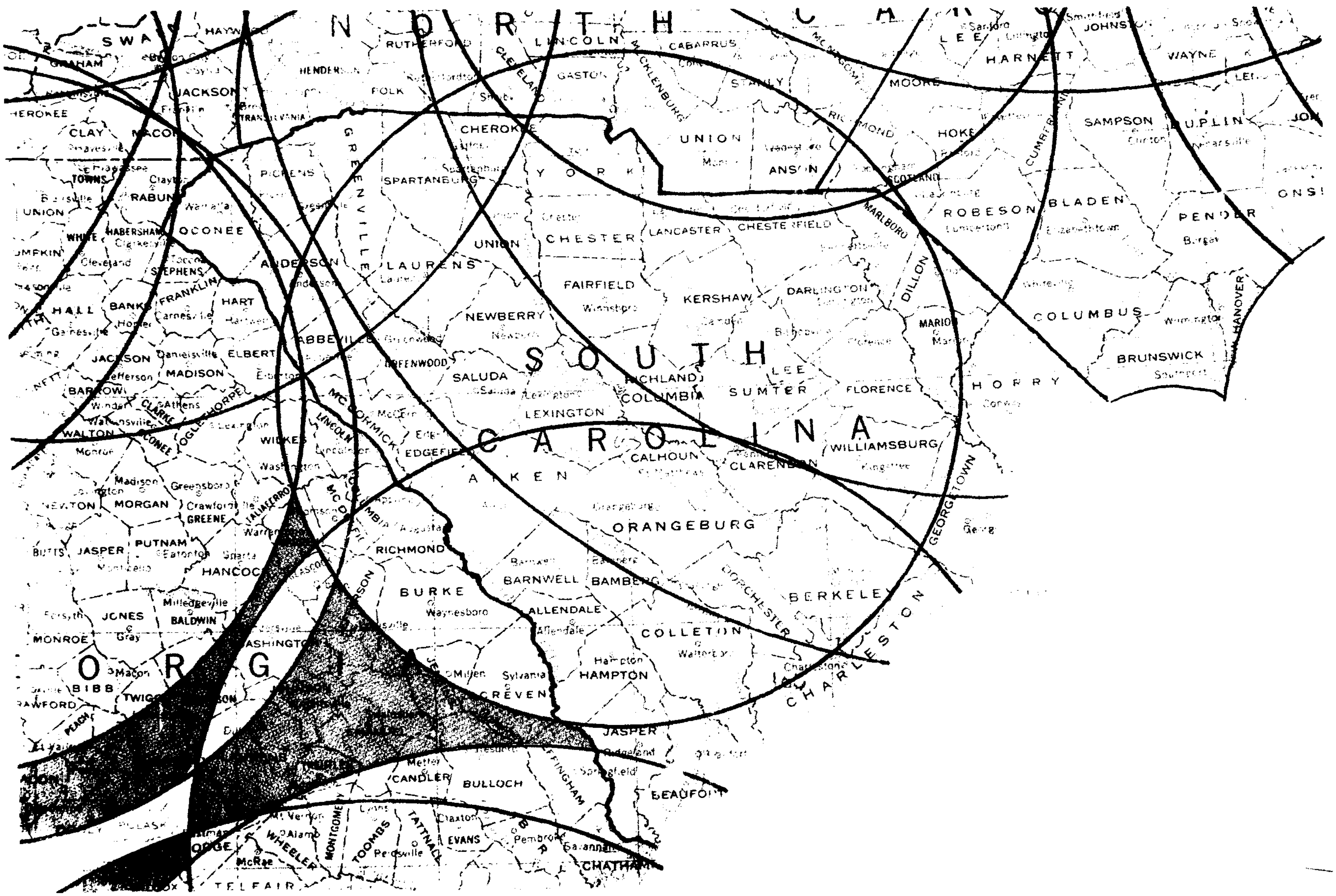


FIGURE A-103 CROSS COUNTRY OPERATING AREA COVERAGE FOR SOUTH CAROLINA

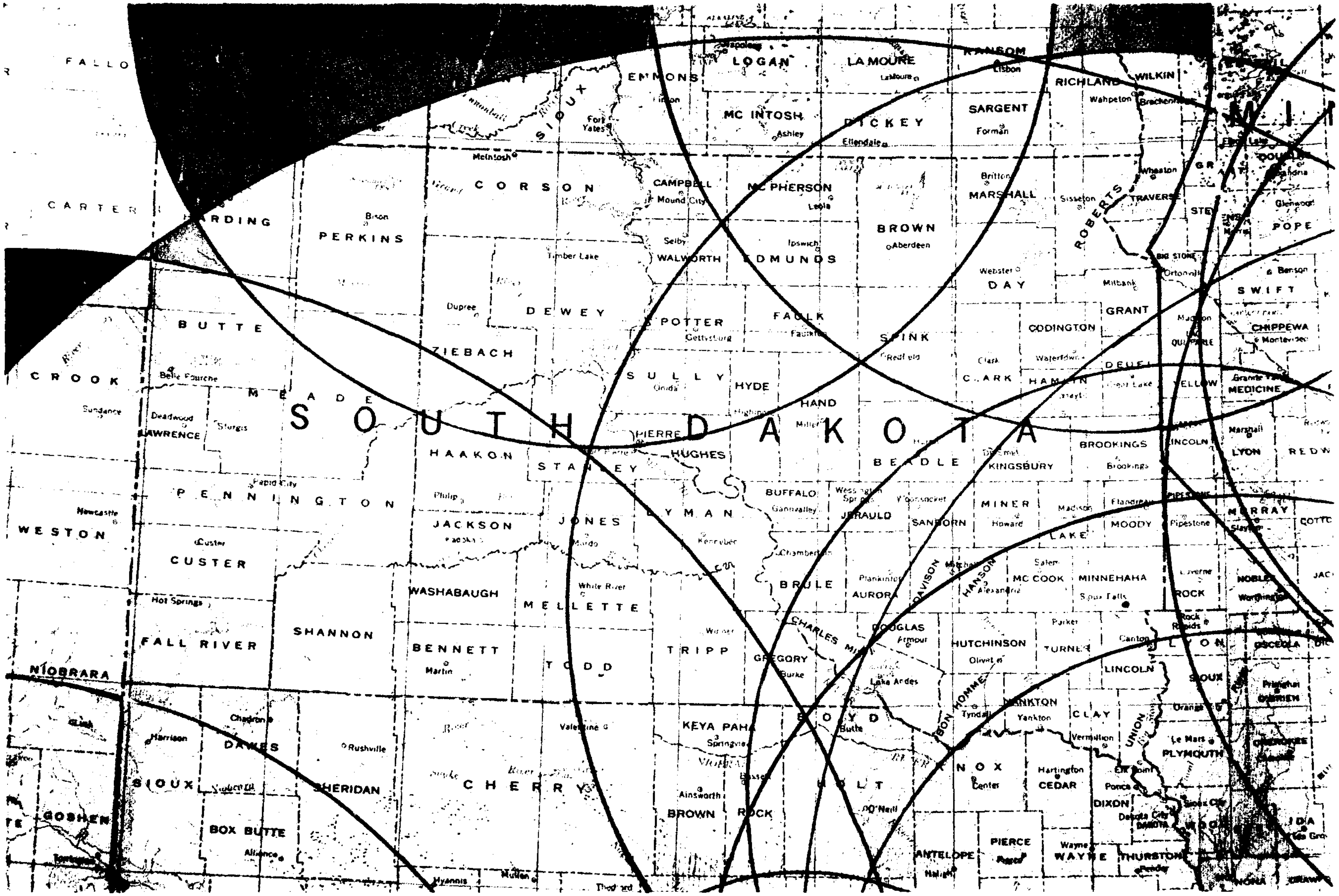


FIGURE A-104 CROSS COUNTRY OPERATING AREA COVERAGE FOR SOUTH DAKOTA

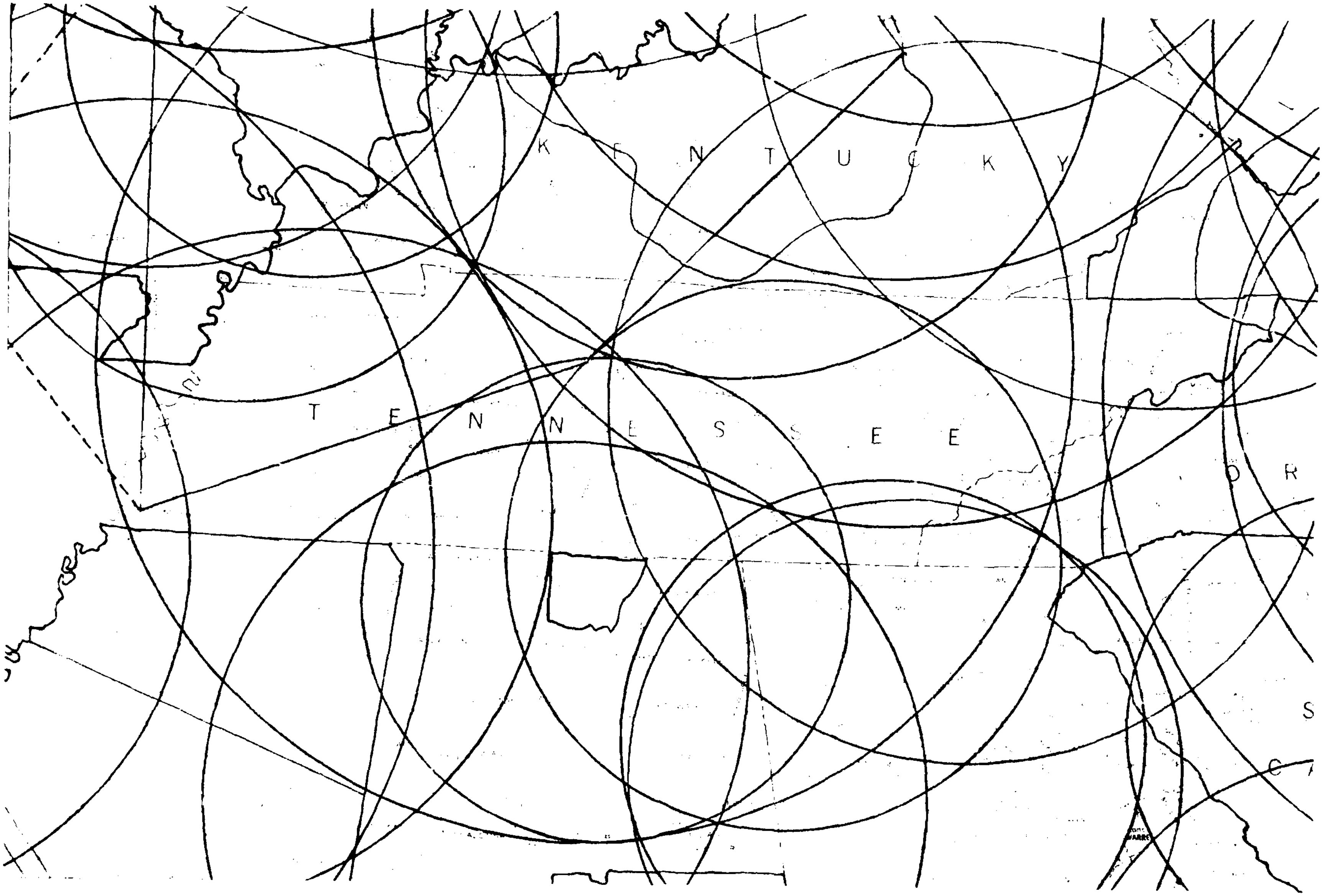


FIGURE A-105 CROSS COUNTRY OPERATING AREA COVERAGE FOR TENNESSEE

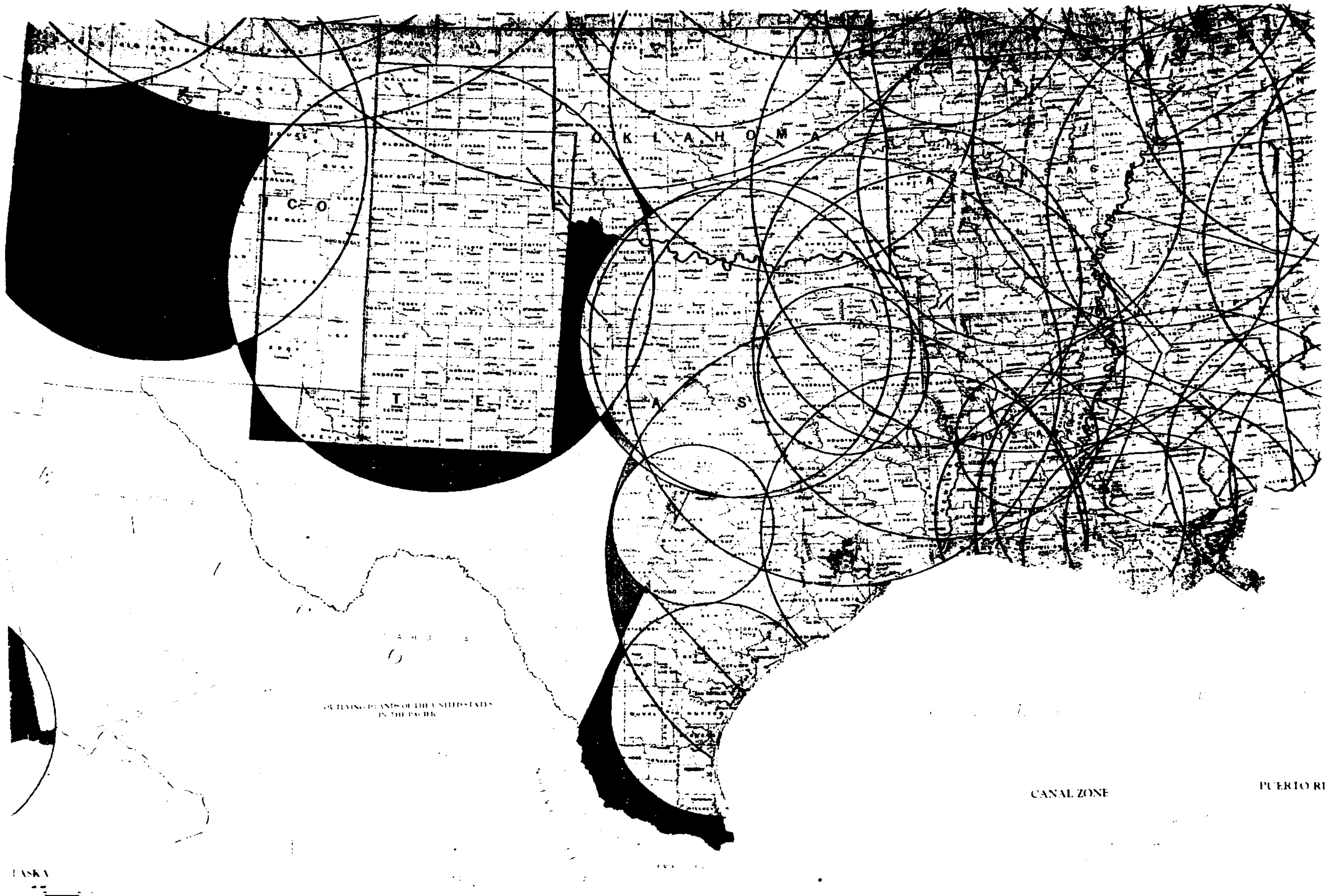


FIGURE A-106 CROSS COUNTRY OPERATING AREA COVERAGE FOR TEXAS

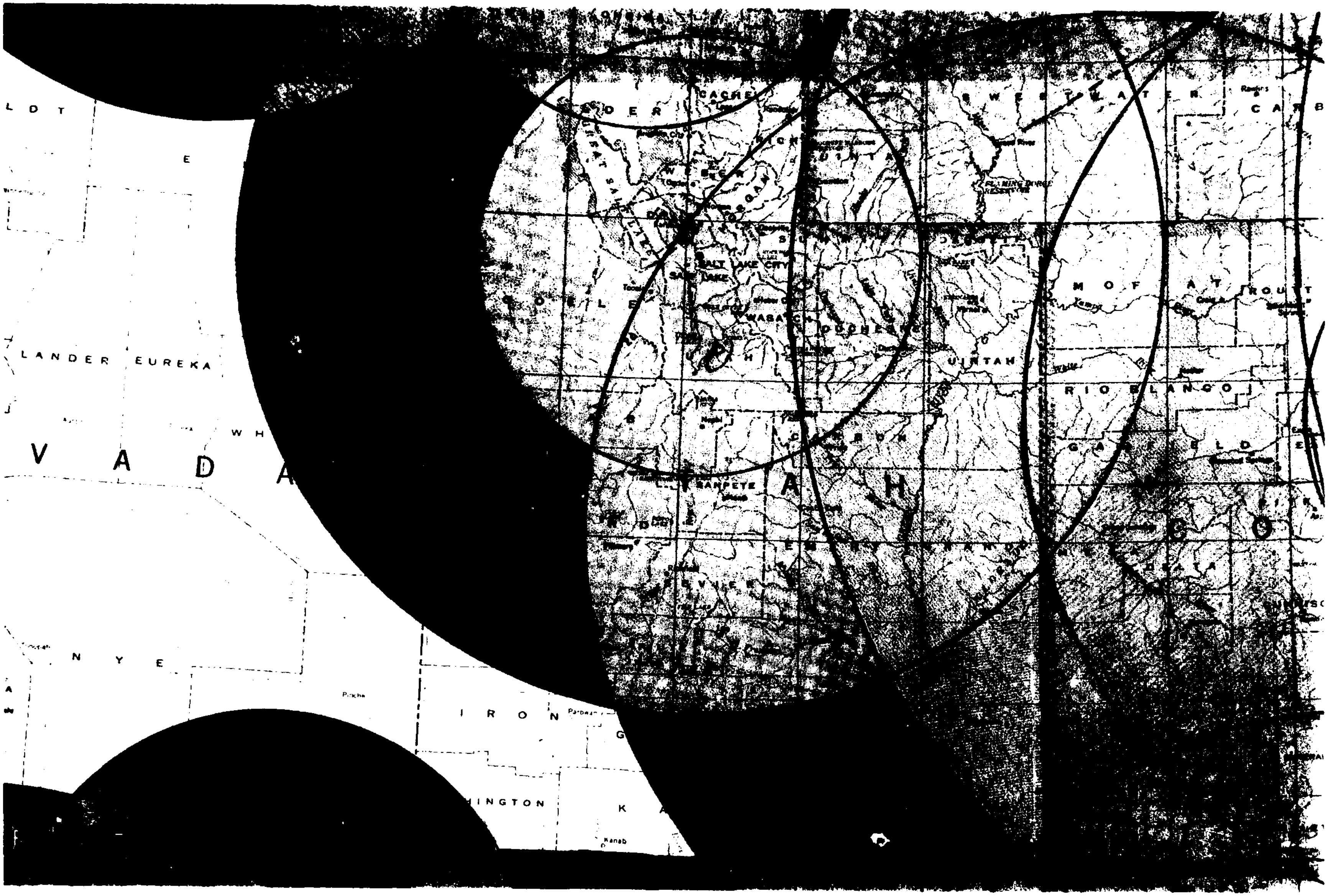


FIGURE A-107 CROSS COUNTRY OPERATING AREA COVERAGE FOR UTAH

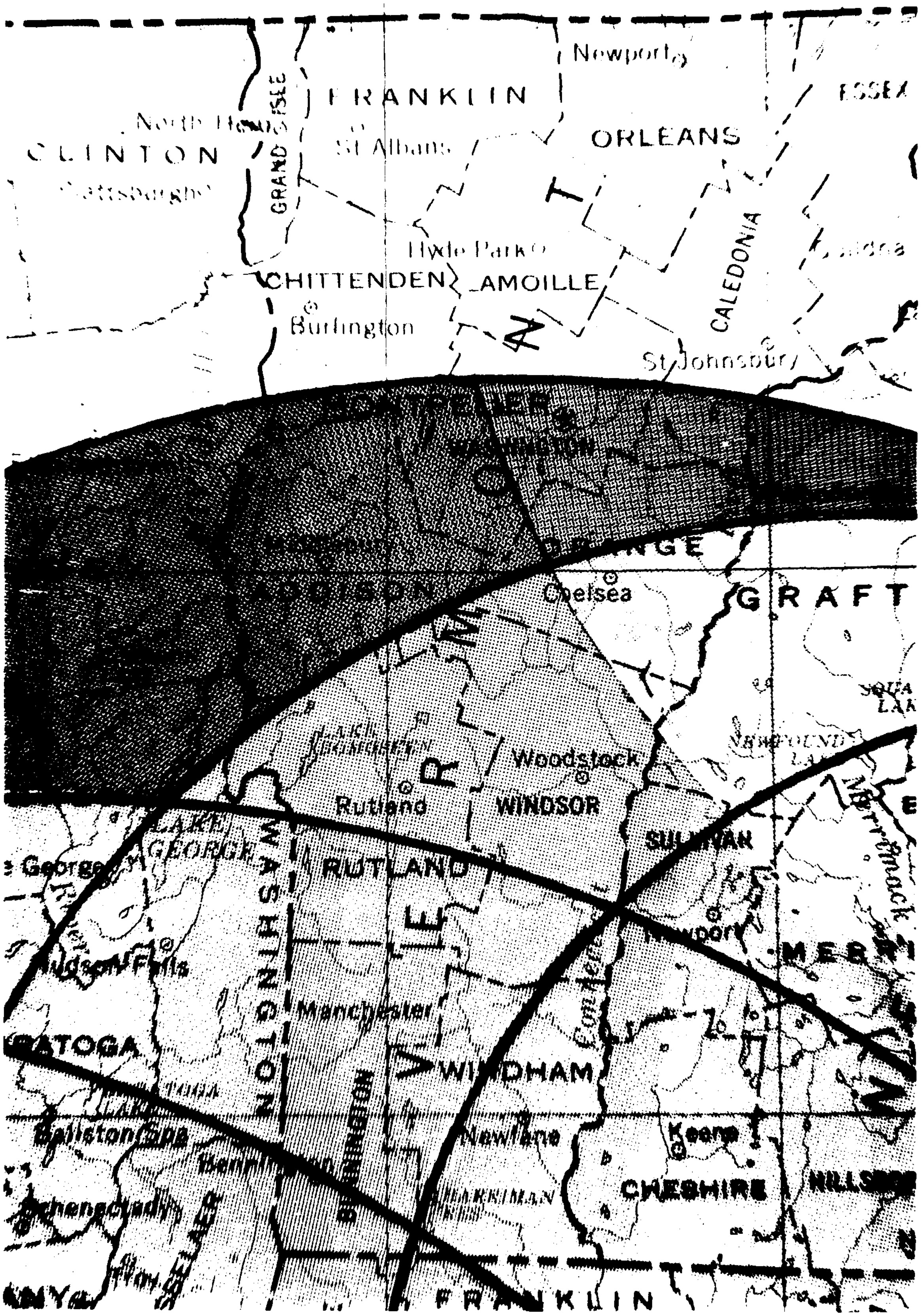


FIGURE A-108 CROSS COUNTRY OPERATING AREA COVERAGE FOR VERMONT

FIGURE A-109 CROSS COUNTRY OPERATING AREA COVERAGE FOR VIRGINIA

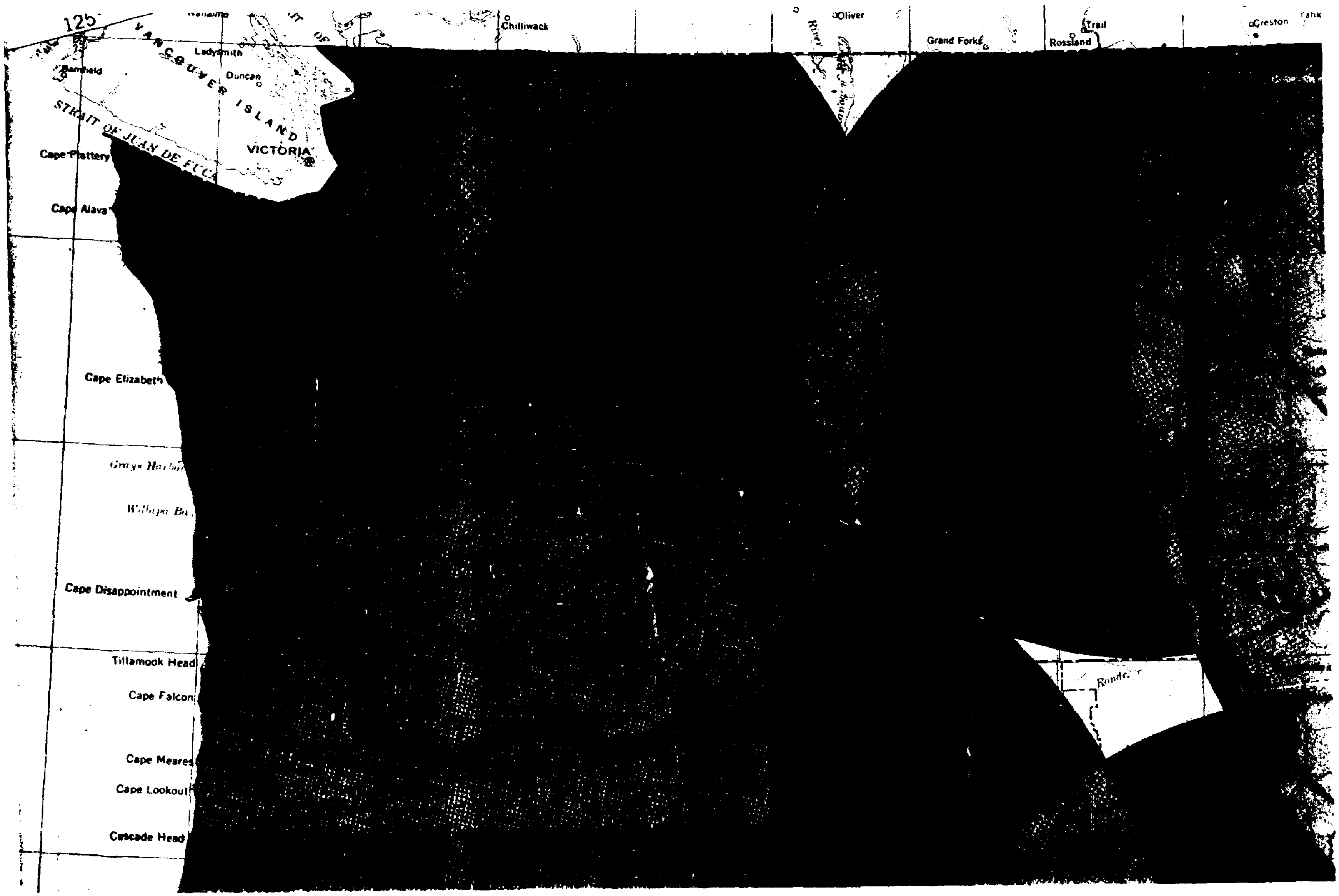


FIGURE A-110 CROSS COUNTRY OPERATING AREA COVERAGE FOR WASHINGTON

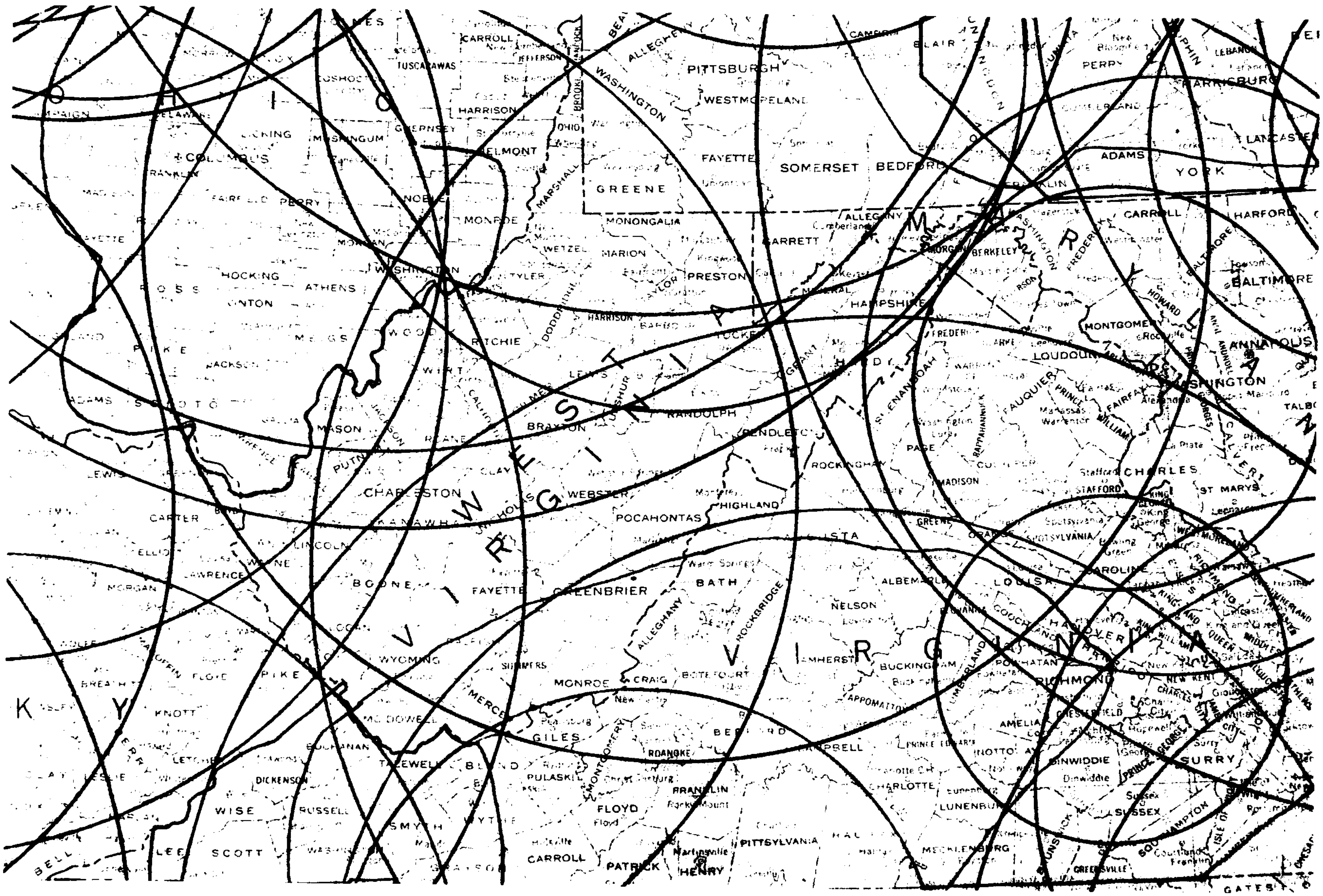


FIGURE A-111 CROSS COUNTRY OPERATING AREA COVERAGE FOR WEST VIRGINIA

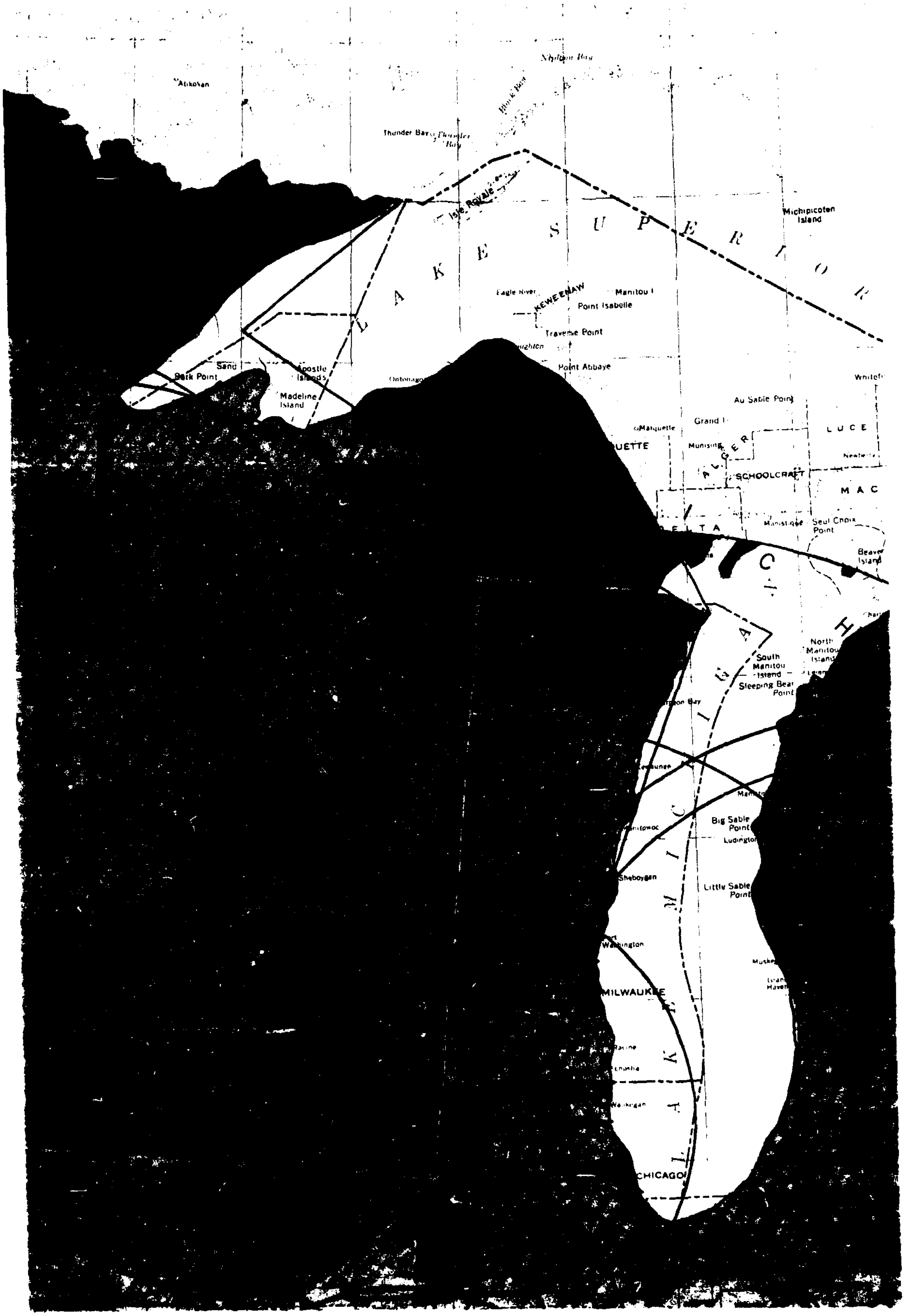


FIGURE A-112 CROSS COUNTRY OPERATING AREA COVERAGE FOR WISCONSIN

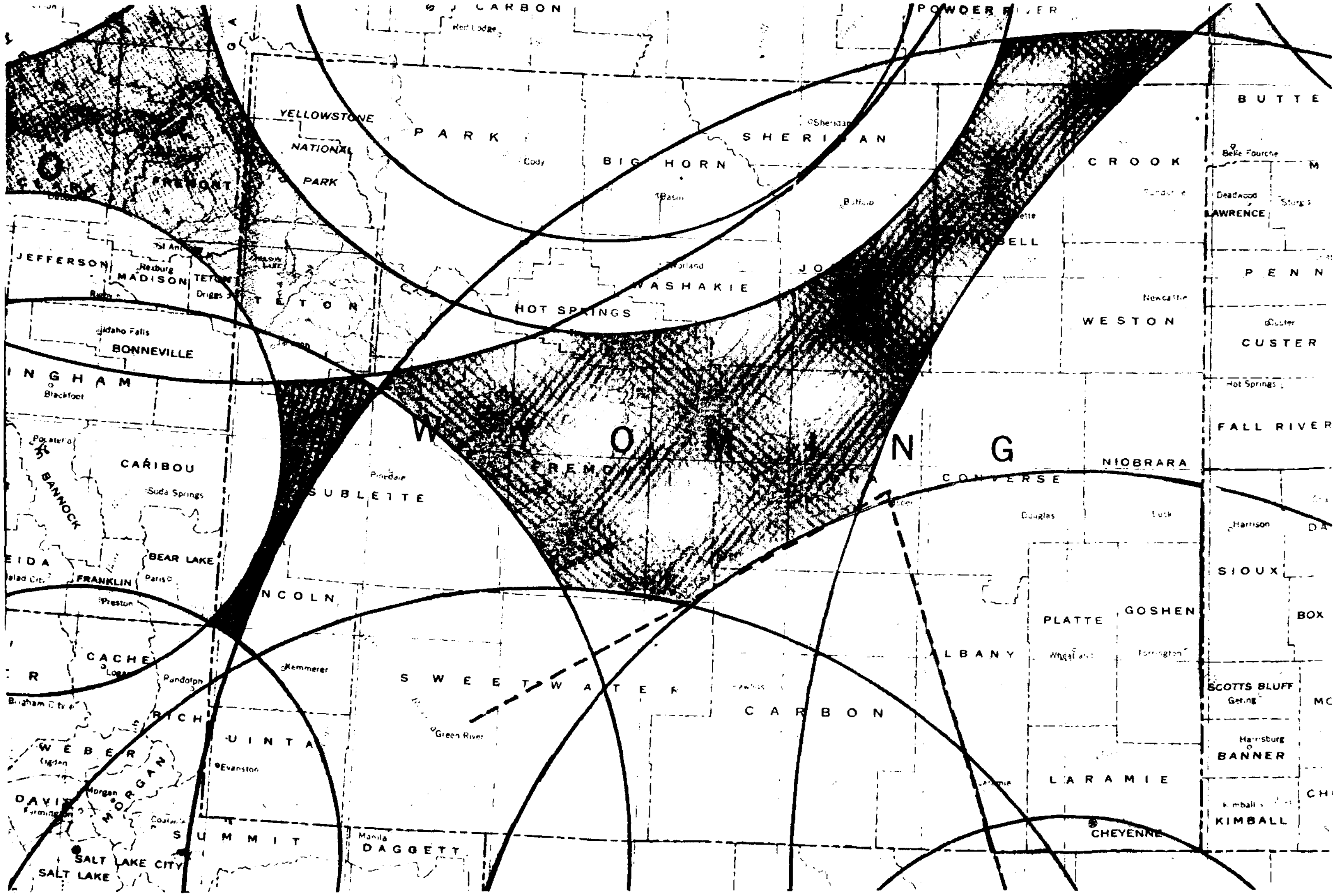


FIGURE A-113 CROSS COUNTRY OPERATING AREA COVERAGE FOR WYOMING

APPENDIX B
SAMPLE QUESTIONNAIRE

U.S. Department
of Transportation

**Federal Aviation
Administration**

800 Independence Ave., S.W.
Washington, D.C. 20591

June 19, 1989

Dear Sir,

The Federal Aviation Administration (FAA) is engaged in a research and development project to determine what areas of the United States should be provided with additional low altitude communication, navigation and surveillance facilities, and associated air traffic control services. The study is being performed as a benefit/cost analysis assessing a wide variety of rotorcraft missions. Based on prior analysis and the evaluations completed thus far in this study, we believe that a large percentage of the public benefits that would accrue from providing additional facilities/services would result from the life saving possibilities associated with the air ambulance helicopter mission. Thus, in our ongoing analysis, we are striving to understand the complexity of the air ambulance mission so as to properly assess services currently provided, additional services required, their cost, and the benefits that may be derived if they are provided.

To properly assess the services provided/needed, we must know the geographic areas in which you normally operate. In a recent advisory circular, Emergency Medical Services/Helicopter (AC 135-14), the FAA recommended (Par 6b (1)), that each EMS dispatch location establish a local flying area and a cross-country area. We have urgent need of that information to support our efforts to provide additional services where it can be shown to be cost beneficial to do so. We are therefore requesting your help in providing us with information concerning your operation. Because operations differ dramatically, with boundaries dictated by terrain, politics, competition, equipment, etc., we recognize that inputs may vary widely. We will sort out the responses when we receive them. We have however provided samples (Attachments 1 thru 3) received from one operator indicating the type of information needed. It is very important that we know any company minimums establiished for local and cross country areas and how they differ day and night. It is our intent to compare existing and planned services to the needs of your operation for purposes of identifying shortfalls.

Please send chart(s) and any necessary textual description of your operating area and minimums to the following address.

Federal Aviation Administration
Mr. Robert D. Smith, ADS-220
800 Independence Avenue S. W.
Washington, D. C. 20591

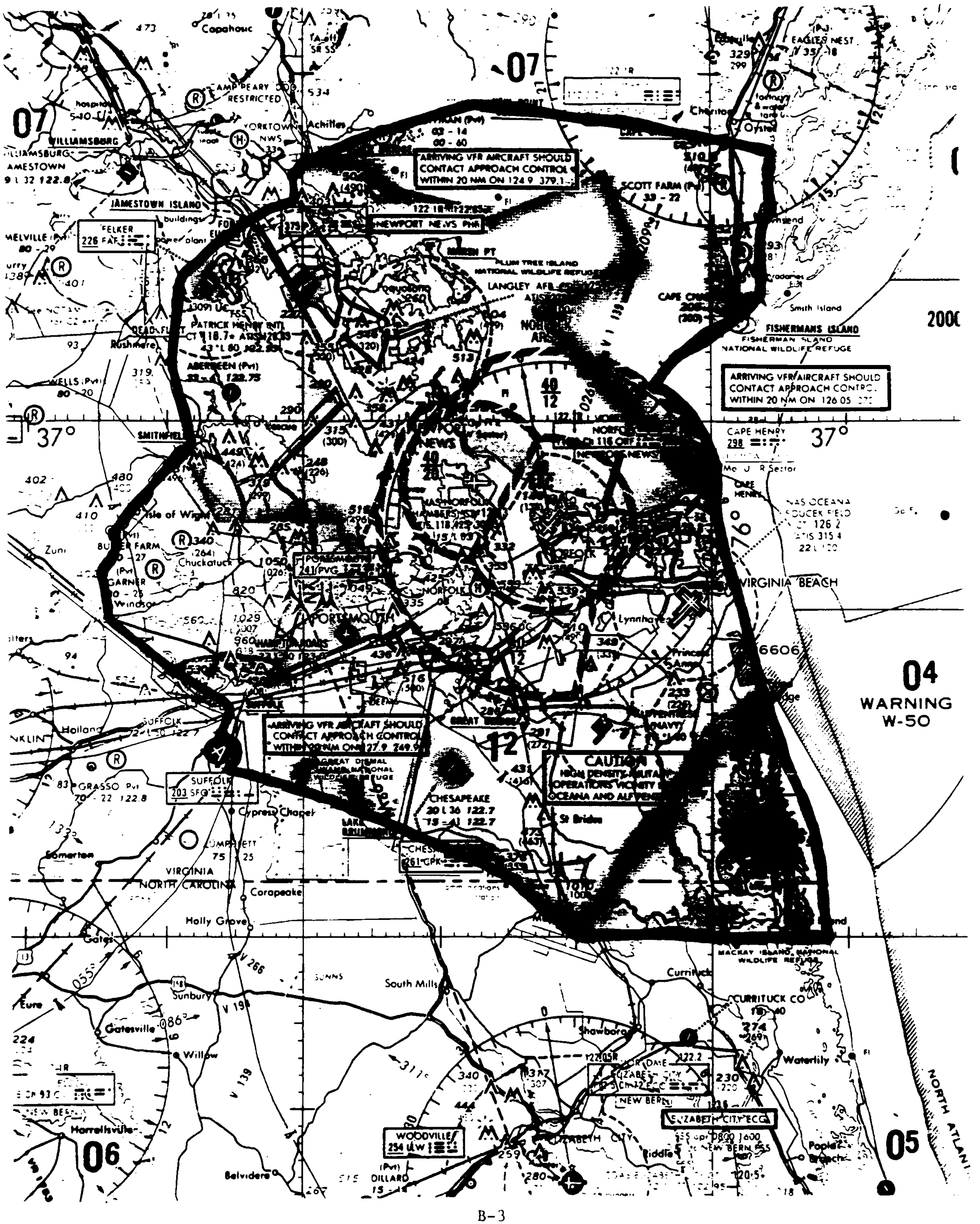
If possible, we would like to receive this material by July 7.

Thank you for your assistance in this matter. Should you have any questions, please feel free to call me at (202) 267-3783. Please be aware that the information we are requesting does not fulfill or eliminate any obligations you may have to your local Flight Standards Office as we are not involved directly in their work.

Robert D. Smith

Robert D. Smith
Rotorcraft Technology Branch, ADS-220

Attachment 1 - Local Area
Attachment 2 - Cross Country Area
Attachment 3 - Weather Minimums


ARRIVING VFR AIRCRAFT SHOULD CONTACT APPROACH CONTROL WITHIN 20 NM ON 124.9 379.1
ARRIVING VFR AIRCRAFT SHOULD CONTACT APPROACH CONTROL WITHIN 20 NM ON 126.05
ARRIVING VFR AIRCRAFT SHOULD CONTACT APPROACH CONTROL WITHIN 20 NM ON 127.9 249.9
CAUTION
HIGH DENSITY MILITARY OPERATIONS VICINITY OCEANA AND FENTRESS
04
WARNING
W-50
37°
VIRGINIA
NORTH CAROLINA
NORTH ATLANTIC
WILLIAMSBURG
JAMESTOWN ISLAND
PORTSMOUTH
NORFOLK
VIRGINIA BEACH
CHESAPEAKE
SUFFOLK
FISHERMANS ISLAND
CAPE HENRY
ELIZABETH CITY
South Mills
Gatesville
Holly Grove
Corapeake
07
12
06
05

Local Operating Area
Cross Country
RESTRICTED
R-5314
PAMLICO SOUND
RESTRICTED
WARNING
W-122 A
ATTACHMENT 2

APPENDIX C
WEATHER DATA MODEL

The weather data provided in the Airport Specific File (ASF) is derived from the national average weather data (NAWD) and corrected with site specific weather data. However, the ASF data is organized in such a way that the joint (combined) probabilities of only eight specific combinations of ceiling and visibility limits being exceeded are reported. For the purposes of this study, unconditional (independent) probabilities are of more value than joint probabilities, since the unconditional probabilities will allow the many varied combinations of ceiling and visibility minimums reported by the operators to be computed. It is not possible to calculate all of the various combinations of ceiling and visibility directly from the ASF data.

For example, one EMS/H operator reported day/local minimums of a 500 foot ceiling and 1 mile visibility. The ASF data contains data for the combined limits of ceiling less than or equal to 400 feet and visibility less than or equal to 1 mile, or for the combined limits of ceiling less than or equal to 600 feet and visibility less than or equal to 1.5 miles. Nothing in between is reported. Neither category in the ASF exactly fits the operator's minimums. The reported probabilities for the two categories are 1.0 percent and 3.38 percent, respectively. The model developed herein computes the joint probability for 500/1 at the operator's location to be 1.6 percent. Thus, it can be seen that a greater degree of flexibility has been obtained by using the independent probabilities than would be possible using the ASF data alone.

NATIONAL AVERAGE WEATHER DATA

Table C-1 contains the national average weather data which was linearly interpolated directly from a table of NAWD in appendix C of the report "Development of Revised and Expanded ASF." Table C-1 gives the average joint probabilities of either the ceiling or the visibility minimums, or both, being exceeded for the entire United States. There are several justifications for the use of linear interpolation on the

TABLE C-1 PLOT OF NATIONAL AVERAGE WEATHER DATA

Ceiling	Visibility (miles)						
(feet)	1/2	3/4	1	1-1/2	2	2-1/2	3
200	1.12	1.52	2.02	3.14	4.46	5.78	7.10
300	1.48	1.79	2.22	3.26	4.55	5.84	7.13
400	2.13	2.37	2.72	3.63	4.85	6.07	7.29
600	3.67	3.84	4.10	4.82	5.88	6.93	7.99
800	5.46	5.60	5.81	6.40	7.32	8.23	9.15
1000	7.24	7.36	7.54	8.05	8.86	9.67	10.48
1200	8.67	8.78	8.95	9.42	10.17	10.93	11.69
1500	10.82	10.92	11.06	11.47	12.15	12.82	13.50

A national average percentage of weather observations with ceilings or visibilities less than selected values. Example: 1.79 percent of the time, the ceiling is less than 300 feet, or the visibility is less than 3/4 mile, or both.

NAWD. The ASF itself uses linear interpolation of NAWD in order to fill gaps in the reported data. The ASF reports eight different combinations of ceiling and visibility minimums, but the data source used in generating the ASF weather data contains only six combinations. Linear interpolation, based on the NAWD, was used to expand the data to eight combinations. In appendix D of the ASF report, there is an explanation of the method of linear interpolation used. In appendix E of the ASF, there are numerous graphs depicting the linear nature of the probability data when either the ceiling or the visibility limit is held constant. The method of interpolation suggested in appendix D of the ASF was not adopted for this report. It was considered to be less accurate than the method described herein, since it relied upon joint probabilities.

Figures C-1 and C-2 illustrate the piecewise linear nature of the national average weather data. Figure C-1 illustrates the piecewise linear nature of the data when the ceiling is fixed. Note that the probability is a piecewise linear function of the visibility for all ceiling values. Figure C-2 illustrates the piecewise linear nature of the data when the visibility is fixed. Note that the probability is a piecewise linear function of the ceiling for all visibility values. Several site specific plots of independent ceiling and visibility probabilities were also developed. In all cases, the plots were found to exhibit the same piecewise linear behavior as the NAWD model.

In order to derive the unconditional probabilities for the ceiling and visibility limits being exceeded, the data was linearly extrapolated to zero percent probability for both the ceiling and the visibility percentages.

Table C-2 is a reconstruction of the NAWD using the unconditional probabilities derived from the NAWD and the CMSI model (described in the following paragraph) for combining unconditional weather probabilities to produce a joint weather probability. Table C-2 presents: 1) the extrapolated values of the unconditional probabilities of a 0 foot ceiling and 0 nm visibility, and 2) the computed values for the same weather data as given for the national average weather data in table C-1.

TABLE C-2 PLOT OF CALCULATED AVERAGE WEATHER DATA

K = 0.813

Ceiling	Visibility (miles)							
(feet)	0	1/2	3/4	1	1-1/2	2	2-1/2	3
0		0.93	1.39	1.92	3.08	4.41	5.75	7.08
200	0.66	1.16	1.58	2.09	3.23	4.55	5.88	7.21
300	1.18	1.52	1.85	2.30	3.39	4.69	6.01	7.33
400	1.86	2.13	2.36	2.71	3.67	4.92	6.21	7.52
600	3.43	3.65	3.80	4.02	4.67	5.67	6.83	8.06
800	5.23	5.43	5.56	5.72	6.20	6.94	7.87	8.94
1000	7.01	7.20	7.32	7.46	7.86	8.44	9.19	10.09
1200	8.45	8.64	8.74	8.88	9.24	9.75	10.40	11.18
1500	10.60	10.79	10.89	11.02	11.34	11.79	12.33	12.98

WEATHER PROBABILITIES

NATIONAL AVERAGE MODEL

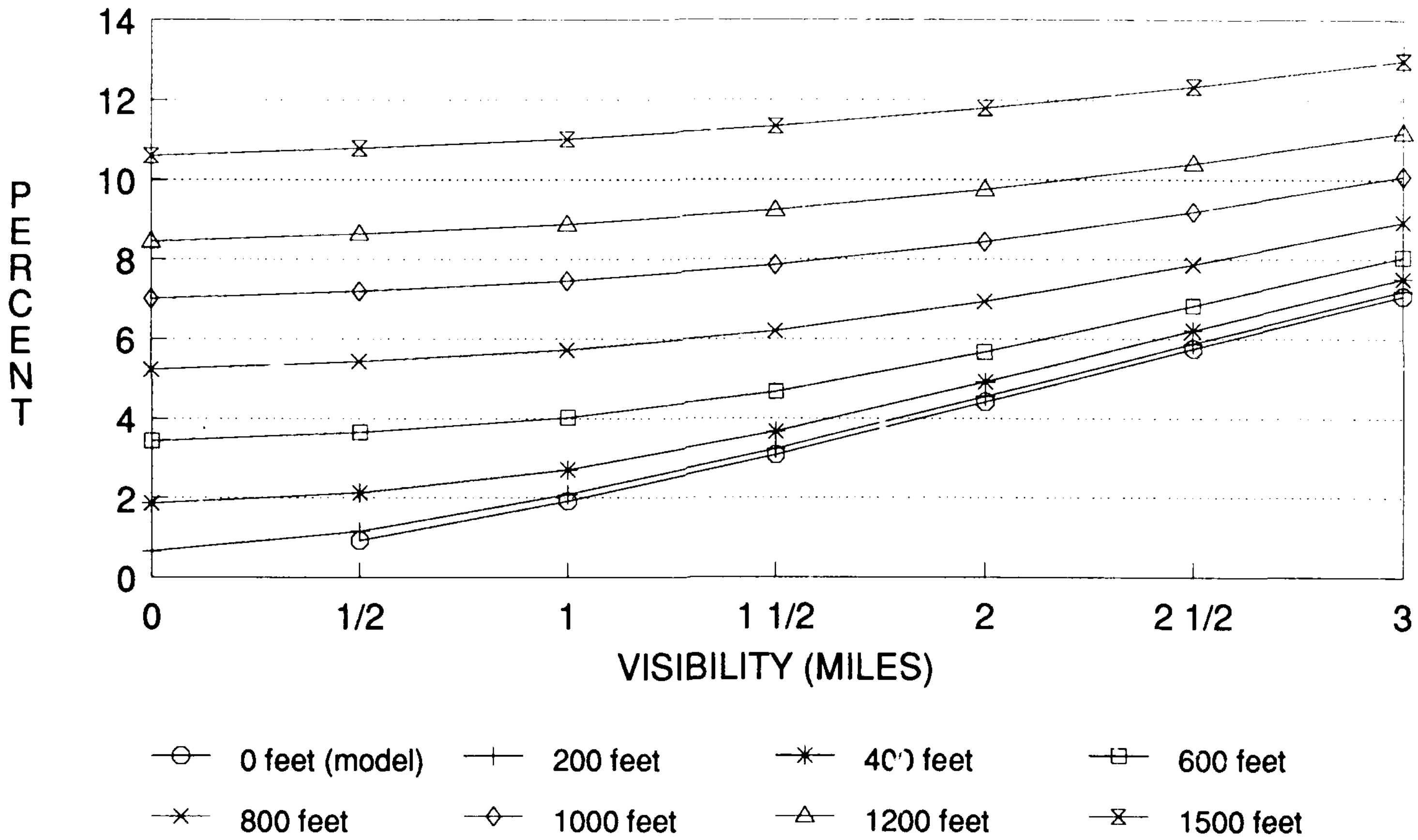


FIGURE C-1 CEILING PROBABILITIES AS A FUNCTION OF VISIBILITY

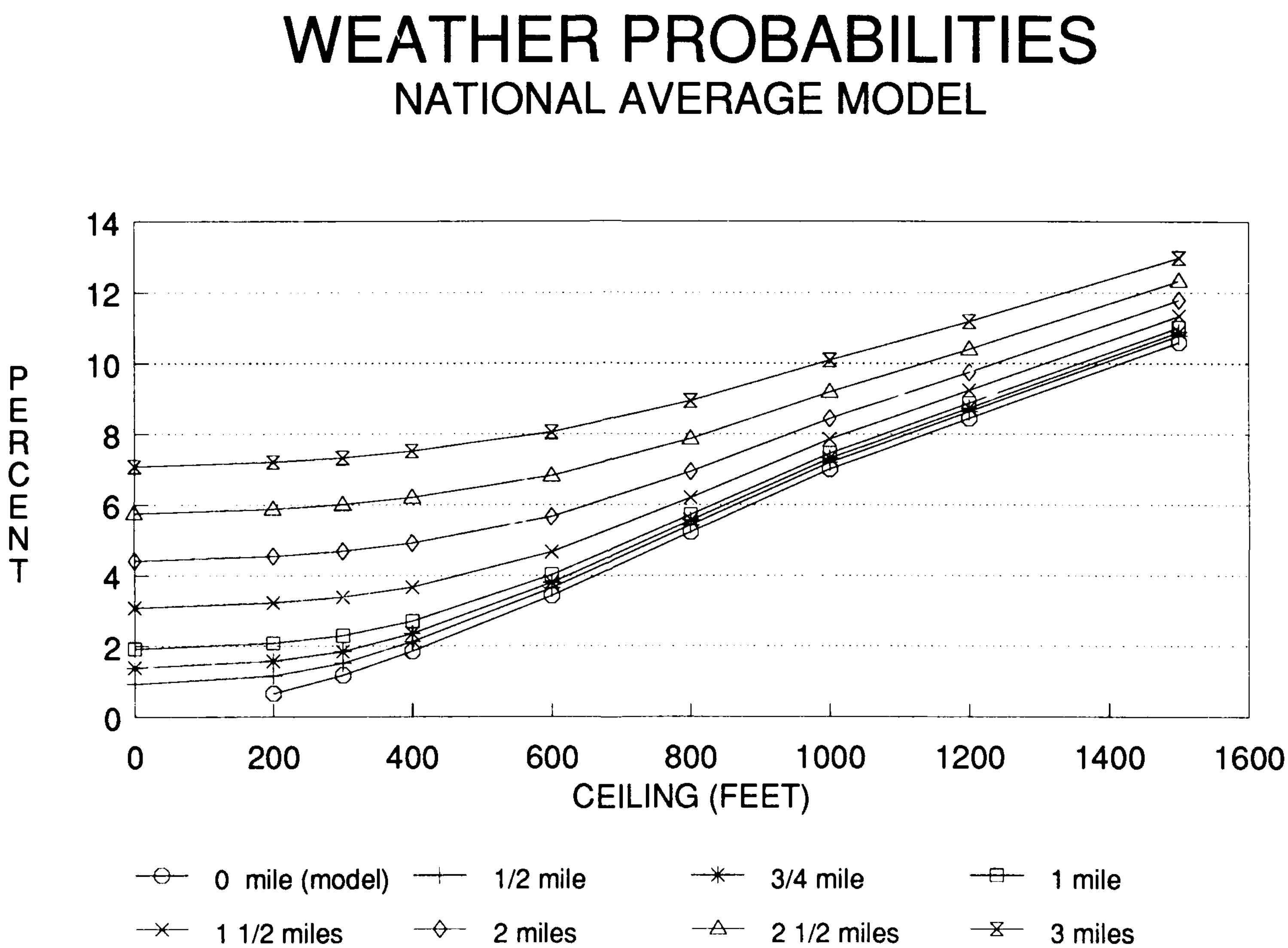


FIGURE C-2 VISIBILITY PROBABILITIES AS A FUNCTION OF CEILING

The computed values are based upon using the independent probabilities from the linear extrapolation in the following Climatic Mission Success Indicators (CMSI) equation:

$$P_{cv} = \frac{(P_c + P_v)}{2} + \frac{(P_c + P_v)^2}{4} - K * P_c * P_v$$

Where P_{cv} is the joint probability of a ceiling/visibility combination
P_c is the unconditional probability of the ceiling limit being exceeded
P_v is the unconditional probability of the visibility limit being exceeded
K is a correlation factor used to represent the dependency of ceiling and visibility probabilities

The CMSI equation can be found in "Climatic Models That Will Provide Timely Mission Success Indicators For Planning and Supporting Weather Sensitive Operations," contract number AFGL-TR-78-0308, page 3, equation 4, where its use is thoroughly explained. Basically, the procedure is to enter the unconditional probability of ceilings, the unconditional probability of visibilities and a K-value into the CMSI equation.

Table C-2 was developed as a check of both the CMSI equation and of the validity of linear extrapolation of the data in the NAWD to produce the unconditional probabilities. First, the average K-value of the NAWD data in table C-1 was computed by using the CMSI equation with the extrapolated 0 foot ceiling and 0 mile visibility values and solving for K instead of for P_{cv}. A K-value of 0.813 was found to be the average for the NAWD. Next, using a K-value of 0.813, the values in table C-2 were calculated. Note that in half the cases the difference is less than 0.1 percent and the difference is never greater than 0.6 percent. In addition, the error is never more than 5 percent of the NAWD value. Thus, it appeared valid to use the extrapolated, unconditional values for ceiling and visibility along with the CMSI equation. This model of the NAWD, called the unconditional NAWD model, was then used to compute location specific weather probabilities.

WEATHER DATA ANALYSIS METHODOLOGY

The unconditional NAWD model was used to calculate the percentage of time that a specific EMS/H operator cannot fly due to the various combinations of weather minimums considered in the main body of this report. Several steps were required before application of the model. First, a computer program was written to compare all of the joint probabilities in the ASF with the joint probabilities computed with the unconditional NAWD model. The ratio of the NAWD model probability to the ASF probability was computed to produce an SS-factor (site specific factor) and stored in a new data base that contains the same eight combinations of weather data as the ASF. This database is used to convert the unconditional NAWD model data to site specific weather probabilities.

The file of SS-factors was converted into a dBASE IV database and linked to the EMS database according to the county of the EMS operator's base. Then, a dBASE IV program was written and used to calculate the percentage of time that each EMS/H operator cannot operate under the

various weather minimums. Before the CMSI equation could be applied in each location, it was necessary to linearly interpolate for the specific ceiling/visibility limits of interest for both the SS factor of the location and for the ceiling/visibility limits in the unconditional NAWD model . Once the program had performed the interpolations, the CMSI equation was applied, and the joint probability was calculated and stored in the EMS database.

APPENDIX D
TOOLS AND METHODS USED TO PRODUCE COVERAGE MAPS

The coverage areas reported by the EMS/H operators were transferred to two 1:2,500,000 scale United States geologic survey maps, one composite map to depict local operating areas and one composite map to depict cross country operating areas. The borders of each operator's area were outlined in ink and covered with a 20 percent shading film. A photographer was commissioned to make half-tone images of the contiguous United States, each FAA region, and each state.

The area covered in each state was measured using a Tamaya Digital Planimeter, model Planix 7. A planimeter is an electronic instrument which computes the areas of irregular shapes using precision rollers in a hand-held cursor. As the cursor is moved across the outline, the two perpendicular rollers record the movement and calculate the enclosed area. For each state, measurements were taken for single, multiple, and total coverage for both the local and the cross country operating areas.

*U.S. GOVERNMENT PRINTING OFFICE: 1991--522-711/40183